1994 SKY EVENTS CALENDAR — FREE INSIDE!

ASTRONOMY

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The Big Bang
Cosmology's Greatest Puzzle

NEW LIFE FOR HST

TELESCOPE TEST:
Tele Vue's Genesis SDF

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- Pluto & Charon: Distant Enigmas
- Comet Encke's Back and It's Bright

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MEADE LX200 EMC
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SMART DRIVE
Meade
ENTER
MODE
GO TO
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12" LX200

10" LX200
(shown with
optional
Superwedge)

8"
LX200

Supplied complete per catalog specifications**:

8" LX200 Schmidt-Cassegrain	**$2295.**
Equatorial Wedge 8"	**110.**
10" LX200 Schmidt-Cassegrain	**2895.**
12" LX200 Schmidt-Cassegrain	**3995.**
Superwedge 10"/12"	**395.**

Packing & shipping in 48 states: 8"—$105; 10"—$145; 12"—$215.

- **All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

- For dealer or catalog information see the **Meade Starfinder Reflecting Telescope** ad in this issue.

LX200 SCHMIDT-CASSEGRAINS:
New Technical Advances for 1994.

Six new technical advances that extend Meade's position at the leading edge of telescope technology:

1. 18-volt Dual-Axis Drive Systems

Systems—All Meade 8", 10", and 12" LX200's now include **18-volt DC power systems,** superseding the previous 12-volt systems, with the result that **LX200 motor torques are increased by about 60%** over previous models. Combined with new, more efficient DC motor electronics, these powerful, high-torque drives, on both telescope axes, yield a level of drive smoothness heretofore unavailable on any commercial telescope.

2. Ultra-reliable Electronic Systems

Systems—Recent electronic refinements in the main circuit boards, the hand controller, and in the control panel electronics have made Meade's new advanced LX200's more reliable than ever before. State-of-the-art improvements in microcircuitry, combined with *thousands* of hours of laboratory and field testing, result in **the most trouble-free serious telescopes ever manufactured.**

3. New *Version 3.20* Software

Software—As recently announced, Meade *Version 3.20* software is the very latest in telescope operating systems and permits **quick (less than 10 seconds!) 2-star alignment** of the LX200 in the altazimuth mode, without requiring your latitude or longitude, without even leveling the tripod. Just use 2 easy-to-find reference stars and the telescope tracks and actuates GO TO with extreme precision.

*For safety reasons AC-powered personal computers should be used indoors only.

Meade 8", 10", and 12" LX200 Schmidt-Cassegrains include an RS-232 serial port (PC connector) on the power panel.

MEADE LX200
COMPUTER DRIVE SYSTEM
LX QUARTZ - DC SERVO MOTOR
SMART DRIVE
Current (mA x 100)
On
Off
N
S
Encoders
RS232
Focuser
Reticle
Keypad
Power 18vDC
CCD
DEC Motor

4. Software Library Options

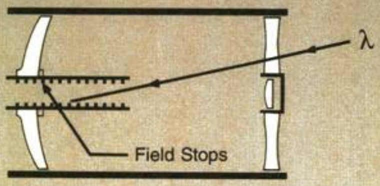
Included with every LX200 is a basic 747-object database of the finest deep-space objects, reference stars, and the 8 major planets. *Version 3.20* LX200 software allows for two new optional object libraries:

—**Library Option 1:** An object database of **10,600** celestial objects taken from the Messier, NGC, and IC catalogs. Available at $99.**

—**Library Option 2:** An object database of **64,350** celestial objects, including the 10,600 objects of Library Option 1, above. Available at $149.**

5. PC-Interface Capability

Meade AstroSearch/200™ sky software permits the interface of a personal computer (PC) to your LX200. Just load Meade AstroSearch/200 software into your PC, connect the PC* to the LX200's PC port (located on the telescope's power panel) and you're ready to **point-and-click on any of 45,000 planetary, deep-space, or stellar objects** now visible on the PC display. As you point-and-click, the LX200 slews at high-speed (up to 8°/second) simultaneously on both axes, precisely centering the object in the field of view. **The Meade AstroSearch/200 celestial software package, supplied on 3.5" discs for Windows™ 3.1 or higher, is available from Meade dealers at $99.95**.**



Field-stops *(arrow)*, now included on Meade 8", 10" and 12" Schmidt-Cassegrains, significantly increase image contrast by effectively blocking off-axis stray light rays, λ.

6. Contrast-Enhancing Field Stops

Field Stops—All Meade 8", 10", and 12" Schmidt-Cassegrains now include a series of computer-optimized internal field stops, for greater rejection of unwanted stray light than ever before possible. These field stops, machined into the inside-diameter surface of the primary-mirror baffle tube *(see diagram)*, **significantly increase lunar, planetary, and deep-space image contrast,** compared to SCT's not so equipped.

Plus all of the features that have already made Meade® LX200's the largest-selling serious telescopes in the world:

- **Legendary Meade Super Multi-Coated (EMC) Schmidt-Cassegrain Optics** —The finest SC optics available, optics that yield razor-sharp stellar images and high-resolution observing of the Moon, planets, and deep-space.
- **Heavy-Duty Fork Mounts**—The largest, most rigid in the industry, complemented by large 4"-diameter polar ball bearings and by DC servo-motor-driven worm gears on both telescope axes.
- **Four-speed Drives on both Telescope Axes**—Including photo-guiding (at **2x** sidereal rate); image centering and microslewing in the main telescope (at **32x** sidereal rate); image centering in the viewfinder (at **2**°/sec.); or fast-slew of the main telescope across the skies (at up to **8**°/sec.).
- **Digital Readouts**—On both axes, read from the keypad hand controller.
- **GO TO Capability**—Enter the RA and Dec of an object into the keypad hand controller, press GO TO, and the telescope slews to the object at up to 8°/sec., centering it in the field.
- **747-Object Built-in Library**—Enter any of the 110 Messier objects, 278 of the finest NGC objects, 351 stars (doubles, variables, reference stars), or one of the 8 planets (from Mercury to Pluto), press GO TO, and the telescope slews at up to 8°/sec., centering the object in the field.
- **Permanently Programmable Smart Drive™** —Capable of reducing periodic drive errors to 5 arc. secs. or less, an observatory standard.

Specifications: 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 SC optical tube assembly with super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; keypad handheld controller with digital readout display, PPEC Smart Drive, four-speed drive control on both axes, GO TO controller, and 747-object software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (DC capability for operation from auto cigarette lighter plug available optionally); 8 x 50mm viewfinder with crosshairs; 1.25" diagonal prism (8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (8", 10") or giant field tripod (12"); foam-fitted carrying case; complete operating instructions.

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Vol. 22, No. 1 January 1994

ASTRONOMY

PULL-OUT BONUS:
Your 1994 Sky Calendar

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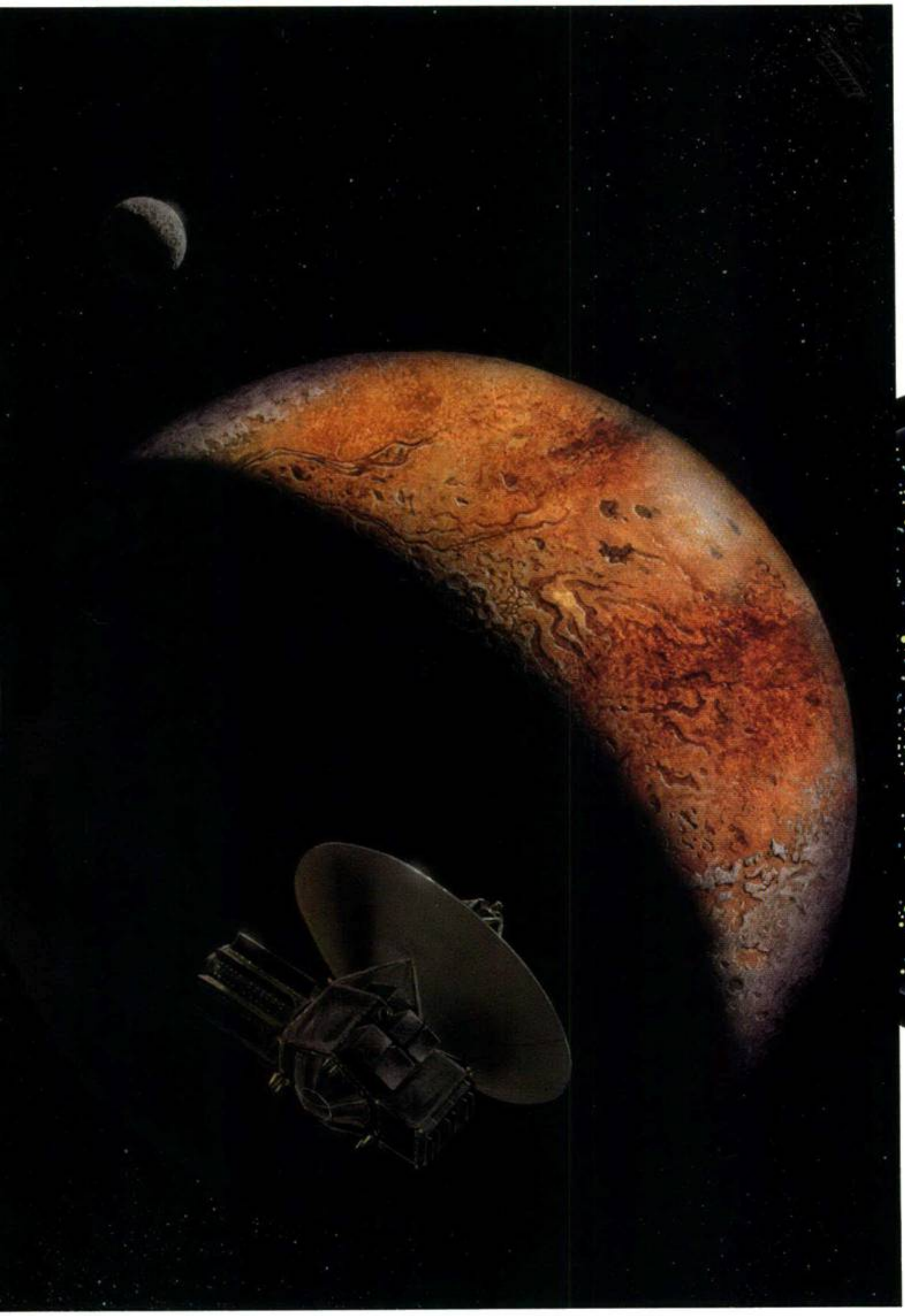

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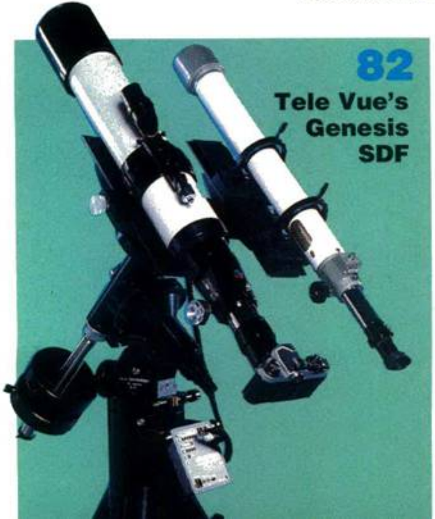

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Stop the jitter. Replace the gyros. Correct the optics. Here's your guide to NASA's ambitious mission to repair the Hubble Space Telescope. By David Bruning.

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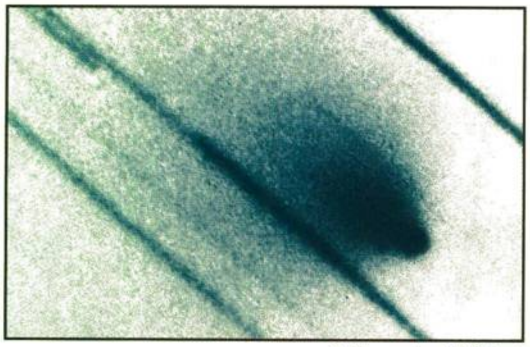

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COVER

THE HUBBLE SPACE TELESCOPE floated in space while being deployed in 1990. Now astronauts are heading back to fix a host of major and minor problems that have cropped up since (see page 36). NASA image.

BEHIND THE SCENES

Help! Is There a Cosmologist in the House?

What is it about cosmology? If the ASTRONOMY staff were to pick the single most popular topic we get letters about, cosmology would win by a big margin. Why does this one subject — "the science of everything" as somebody once called it — draw so many people so strongly?

It's certainly not practicality. The vast doings of the universe at large haven't the slightest effect on you or me. Nor can you see cosmology in your backyard telescope. The Moon? Sure. Planets, stars, nebulae? You bet. The cosmic microwave backgound radiation . . . ? Get real.

Let's face it, our perennial fascination with cosmology is, at bottom, wholly intellectual or even spiritual. Cosmology is all about beginnings and ends and everything in between. From earliest times till now, and in all sorts of guises, it has absorbed some of humanity's best efforts of the mind. Cosmology is also one field of astronomy — maybe the only field — where amateur thinkers feel entitled to hold their own with professionals. Is there a cosmologist in the house? Oh, yes, indeed. I'd say every house in the world contains at least one cosmologist.

Well, sort of. The snag is that cosmology as you or I practice it over a couple of beers with friends and as practiced in the pages of *The Astrophysical Journal* aren't really the same thing. For some amateurs, there are misunderstandings about the Big Bang, for instance. (At one point, we were tempted to call this month's lead feature "Everything You Know About the Big Bang Is Wrong.") Some people see big bang cosmology as an orthodoxy to be resisted, while others view it as simply the most useful model going, however flawed. In any case, to bridge the gap between amateur and professional, we thought it might be interesting to explore some ideas in modern cosmology — but in language ordinary folk can understand. Assistant Editor Rich Talcott took on the challenge and you'll find his feature beginning on page 28.

Now, to leap from the infinite depths of space and time to the magazine in your hands. . . . As you flip through this issue, you'll notice that we've tweaked the appearance a little. Don't worry — all your favorite features are right where you've always found them, but we've taken a fresh look at their design. For example, we updated the department heads so you can find them more easily, and we reorganized Sky Almanac to better showcase each month's celestial events. The news sections also have a new look and you'll find more stories. In these and all other changes, our goal is to provide you with the best information available and present it in the most attractive way. We hope you like it. Let us know what you think.

Lastly, don't miss the 1994 Sky Calendar insert in the center spread. Pull it out and keep it with your star atlas and logbook. It's our New Year's gift to you — a handy guide to the year's great celestial events.

Sincerely,

Robert Burnham
Editor

LETTERS

Fossil Life on Mars

Christopher P. McKay's article on possible early life forms on Mars raises some relevant points. The oldest life on Earth arose about 3.5 billion years ago. Sophisticated geological study and laboratory chemical and isotopic analyses have not provided convincing evidence that life existed in Earth's oldest sediments. An example is the Isua sequence in Greenland. As a geologist, planetologist, and geochemist, I would consider it a futile task to look for definitive life in the Archean rocks of Earth by means of orbiting spacecraft, sophisticated rovers, or even robotic sample return. Life on Earth took two billion years before anything more sophisticated than bacterial mats evolved and, indeed, visually obvious fossils are extremely rare in rocks older than 570 million years.

The possibility for life on Mars appears to have shut down quickly. The use of the word "fossils" by McKay brings up images of shell fragments and is misleading at best when applied without amplification to potential Mars microbes. Even a stromatolitic algal mat can hardly be confirmed (if even suggested) by remote sensing. No significant advance can be made on defining the existence of life on Mars before humans capable of sophisticated geological field studies go there to do so. There is no justification for McKay's statement that the early conditions on Earth and Mars were "remarkably" similar: We have far too little information about either!

The story's emphasis on life on Mars is, in my opinion, detrimental to the study of Mars. Of course it would be exciting if we found life on Mars. But Mars is exciting in any case and should be studied for what we can really discover, including its magmatic, cratering,

(continued on page 12)

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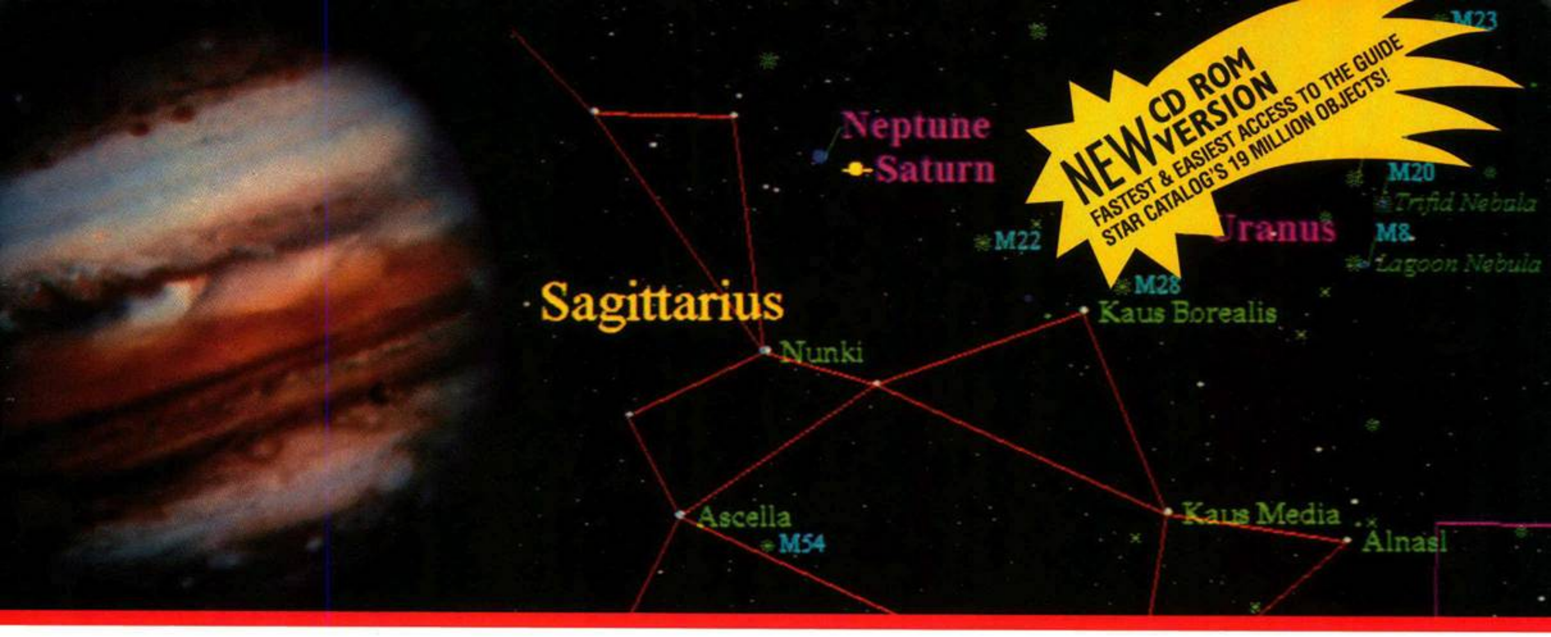
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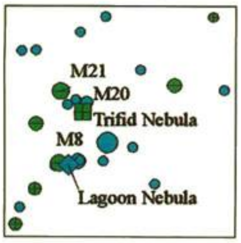

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Arthur C.Clarke

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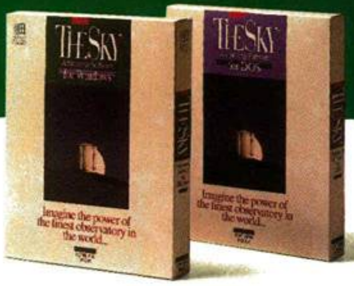
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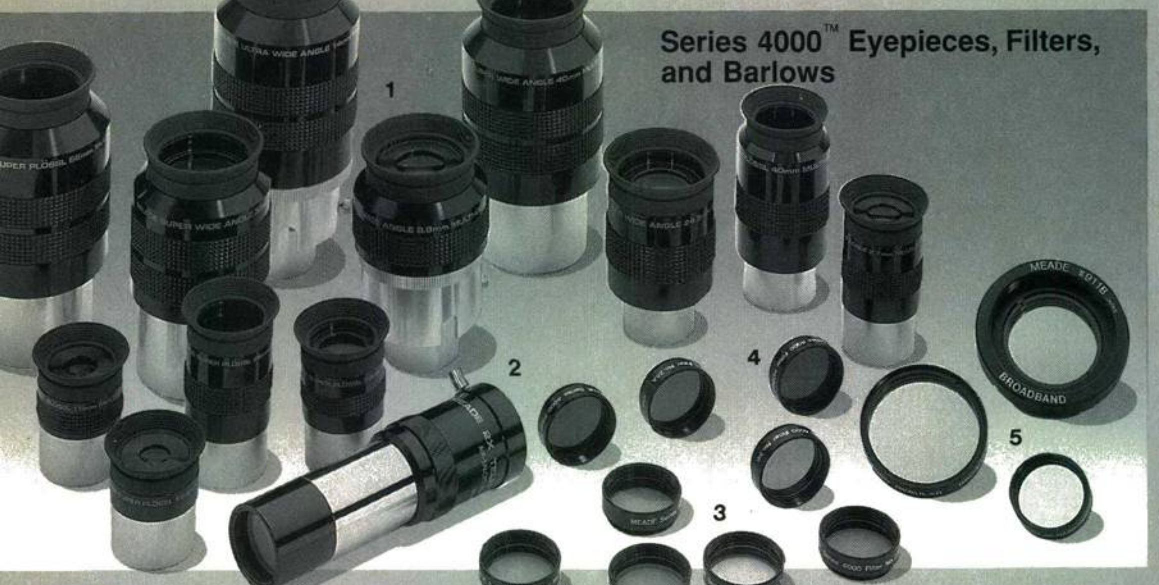

1 The World's finest telescope eyepieces now include rubber grips and soft rubber eyeguards for an even better observing experience! All eyeguards fold down for eyeglass wearers—a feature not available on competing brands. Best of all, **Meade Series 4000's are guaranteed to deliver more field, more contrast, and more image sharpness than any other brand at any price, or your money back.*** For splitting the closest doubles, revealing tenuous, faint nebulosity in deep-space, or studying hairline lunar and planetary detail, Meade multi-coated Series 4000's are the oculars that serious observers insist upon. ***"Clearly the best."***

Super Plössls (5-elements; 1.25"; 52°):
6.4; 9.7; 12.4; 15; 20; 26mm ea **$87.95** (3.29)
32mm(52°); 40mm(44°); each **109.95** (3.79)
56mm (52°, 2") **229.95** (4.78)

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Ultra Wide Angles (8-elements, 1.25"; 84°):
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*at participating dealers; see catalog for details.

2 **#140: Series 4000 2x Apochromatic Barlow Lens** (1.25")--The original Meade 3-element, air-spaced, multi-coated design. Absolutely unmatched in image resolution and color correction. 28mm dia. lens (26mm clear aperture). **$79.95** (3.29)

3 **Series 4000 Photo-Visual Color Filters** (1.25")—Made of purest crown optical glass, dyed in the mass. For increased contrast on the Moon and planets . Thread into virtually all 1.25" eyepieces sold today. Fully coated.
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4 **Series 4000 Moon Filter** (1.25")—Excellent for 4" to 12" telescopes. Reduces Moon brightness by 87%. **$15.95** (2.49)

5 **Series 4000 Nebular Filters**—The very latest in multi-layer interference coating technology, Meade premium nebular filters are guaranteed to be the finest obtainable at any price. Use a Series 4000 Broadband filter to block most forms of light pollution, with minimal attenuation of desired wavelengths. Use a Narrowband filter in heavily light-polluted areas, or for extremely high contrast observing of faint nebulae.

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#910B—Threads into all Meade 2" eyepieces and most others; 44mm dia. **119.95** (2.79)

#911B--Threads on to the rear cell of Schmidt-Cassegrain telescopes. **99.95** (3.29)

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#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter **$99.95** (3.29)

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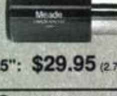

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-Mount, available separately.

.965": **$27.95** (2.79) 1.25": **$29.95** (2.79)

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For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Use with T-Mount for your camera.

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#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (3.29)

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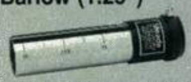

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25" **$59.95** (3.29)

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each **$49.95** (2.79)

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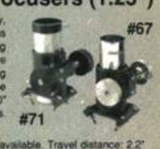
An improvement on the traditional Kellner design, the 3-element MA gives sharp, faithful, well-corrected images of the Moon, planets, and deep-space. Multi-coated; threaded for filters. 1.25" **Focal Lengths: MA 9, 12, 25, 40mm.**

each **$37.95** (2.79)

Rack-and-Pinion Focusers (1.25")



The finest focusers in the industry. Meade rack and pinion mechanisms have precise, ultra-smooth action along the entire travel distance. Housings are machined for tight fit of the moving sleeve. All focuser models may be used on tubes of from 4" to 20" diameter; all accept 1.25" eyepieces. Mounting hardware included.

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#637: 6 x 30mm--Fine, 7° wide-field finder; coated, achromatic lens; crosshair eyepiece, 2-ring bracket with alignment screws. Attaches to tube diameters 6" to 12" **$49.95** (3.29)

#545: 8 x 50mm-*(lower photo)* Wide 5° field; coated achromatic objective; crosshair eyepiece. White tube. Ideal for telescopes of any aperture. See bracket below. **69.95** (4.28)

#544: 8 x 50mm--Same as #545, but in Meade blue. **69.95** (4.28)

#957: 9 x 60mm--*(top photo)* Collects 44% more light than 50mm; superior for faint objects; bracket below. **99.95** (4.68)

Bracket for 8 x 50mm: Fits Meade and Celestron SCT's, and other tubes from 7" to 20" diameter. **17.95** (2.79)

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Originally developed by Meade Instruments, these convenient diagonals erect the astronomical image, for terrestrial use of astronomical telescopes. Fully coated.

#927: for .965" focusers.
#928: for 1.25" focusers.
#931 Hybrid: accepts 1.25" eyepieces, fits .965" focusers.

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■ Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.

■ Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.

■ Meade accessories may be ordered from any Meade Advanced Products dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
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SHUTAN CAMERA & VIDEO, Chicago, IL.
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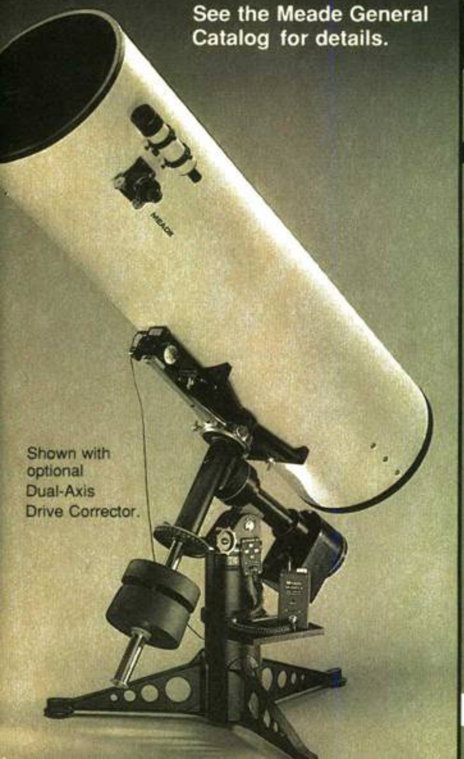

Shown with optional Dual-Axis Drive Corrector.

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■ **Superb Optical System:** Includes a Meade hand-figured parabolic primary mirror that meets the theoretical limit of resolution for its aperture, with matching elliptical flat secondary mirror. Both mirrors multi-coated and made of fine-annealed Pyrex® glass.

■ **Precision Equatorial Mount:** Manufactured of virgin aluminum castings machined to tolerances of .001" or better, and placed atop a 4"-dia. pier with die-cast tripod legs, yielding rock-solid support for the optical tube assembly. The telescope moves effortlessly from object-to-object on precision bearing surfaces. Polar and declination shafts are 1" solid steel. Setting circles on both axes facilitate the location of faint sky objects directly from their catalogued coordinates.

■ **Electric Motor Drive** (115v./60Hz) with 6 ft. power cord: Permits fully automatic tracking of celestial objects; plugs into any standard outlet.

■ **Accessories and Components:** Meade Starfinder telescopes include high-performance components throughout: **Rack-and-Pinion Focuser** (1.25") for smooth, backlash-free focusing of the image; a coated achromatic **#637 6 x 30mm Viewfinder** with crosshair eyepiece and 7° field, for quick object-locating; **coated MA 25mm** (1.25") eyepiece; strong, durable spiral-wound **optical tube** with attractive white finish; and **cast aluminum mirror cell** for accurate mounting and alignment of the primary mirror.

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A Meade Starfinder telescope opens up the skies to an extremely wide range of serious visual observing, to lunar and planetary photography, and even to limited deep-space photography. And every telescope is backed by the World's largest manufacturer of serious telescopes.

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New LXD 650 and LXD 750 Equatorial Mounts: Identical in external appearance to their predecessor LXD 600 and 700 mounts, new Meade LXD 650 and 750 mounts include important internal technical advancements for 1994:

- **Redesigned worm gear systems**—New worm gear engagement assemblies **virtually eliminate gear backlash**, resulting in the most rigid, flexure-free mountings available.
- **Optional #1697 Computer Drive System now with 18-volts Power Input**—RA and Dec motor torques of the #1697 CDS are now **increased by 60%** from the values of the previous 12-volt systems. These powerful, high-torque systems yield extremely smooth motion of the telescope even in the 8°/sec. fast-slew mode. Each CDS includes an 18v.DC power supply, operable from standard 115v. outlets.

If you're looking for the most advanced, super-high-resolution refractors available, and yet priced within the budget of most serious amateurs, call or visit your authorized Meade dealer today.

Complete ED Apochromatic Refractors*

Specifications—Each complete telescope includes optical tube assembly with #684 giant 2.7" focuser, 8 x 50mm viewfinder, #930 2" diagonal mirror with 1.25" adapter, and Super Plössl 26mm eyepiece; 4" and 5" models include the LXD 650 equatorial mount and standard field tripod; 6" and 7" models include the LXD 750 equatorial mount and giant field tripod; each mount is provided with manual slow-motion controls, analog setting circles, and locks on both axes.

Model 102ED:	4" f/9 ED/APO complete	**$2195.**
Model 127ED:	5" f/9 ED/APO complete	**2795.**
Model 152ED:	6" f/9 ED/APO complete	**4495.**
Model 178ED:	7" f/9 ED/APO complete	**5495.**

Packing & shipping in the 48 states: 4"--$105; 5"--$125; 6"--$185; 7"--$215.

#1697 Computer Drive System (CDS): Includes 4 dual-axis drive speeds (2x, 32x sidereal, 2°/sec. 8°/sec.); Smart Drive; keypad hand controller with digital readouts; GO TO capability from input RA and Dec or from 747-object library—**$695.** 8000-object CNGC library available separately at **$99**.

Meade ED/APO Optical Tube Assemblies and LXD 650 and 750 Equatorial Mountings are available for separate purchase; see the Meade General Catalog for details.

8″ Model 2080A:
$1099.*

10″ Model 2120A:
$1379.*

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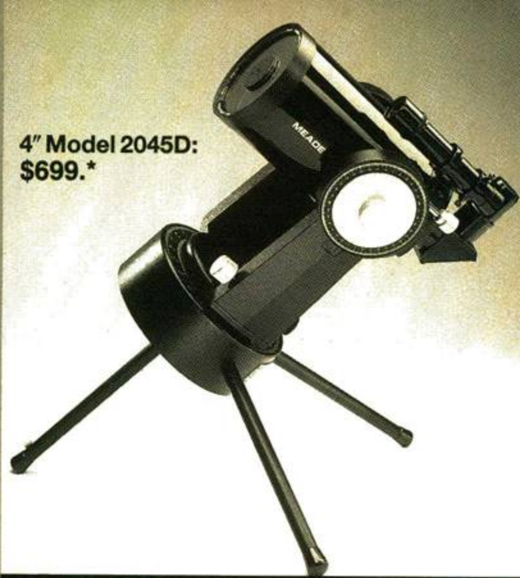
■ **Mountings:** Highly stable, low vibration fork mountings designed for advanced applications such as long-exposure astrophotography, mountings that can carry more than *twice the payload* of competing small German-type mounts.

■ **Standard-Equipment Motor Drive System:** Not an add-on, but a *built-in 5.75″ worm gear drive that is the most accurate available on any SCT in this price range.*

■ **Variable-Height All-Metal Field Tripods:** The finest tripods yet developed for SC telescopes, the ultimate in rigidity and low-damping time.

■ **Optional Systems:** Unlike competing German-mounted SCT's with small worm gears, Meade Standard Series SCT's permit almost unlimited growth potential—use the **#46 Dual-Axis Drive Corrector** for deep-space photography with the **Off-Axis Guider** system; **#929 2″ Diagonal** with **2″ Super Wide Angle** eyepieces for breathtaking wide-field observing; and much more. ***See the Meade catalog for details!***



4″ Model 2045D:
$699.*

4″ Model 2045D: the Ultraportable Meade SCT

For the beginning astronomer the lightweight and easy-to-use Meade 2045D packs a powerful potential for serious observing. As a second telescope for the advanced amateur, the 2045D permits wide-ranging observations in locations inaccessible or inconvenient to larger instruments. Each telescope includes optics manufactured to the same high performance standards as larger Meade models. The DC drive system operates from a micro battery pack for convenient field use. Full accessorization is available for virtually any field application.

Specifications: Model 2045D—Complete with 4″ f/10 Schmidt-Cassegrain tube assembly with super multi-coated optics; fork mount with setting circles, manual slow-motion controls, and locks on both axes; 12-volt DC pulse motor, spur gear drive system; AA battery pack (batteries are not included); tabletop tripod system; eyepiece holder/diagonal prism; coated MA 25mm (40X) eyepiece (1.25″); 5 x 24mm viewfinder. .... **$699.**

Packing and shipping in the 48 states .... **$40.**

Specifications: 8″ Model 2080A—Complete with 8″ f/10 Schmidt-Cassegrain optical tube assembly; fork mount with setting circles, manual slow-motion controls and locks on both axes; 5.75″ worm gear motor drive system (115v./60Hz); eyepiece-holder (1.25″); diagonal prism; coated MA 25mm eyepiece (1.25″); 6 x 30mm viewfinder; equatorial wedge; variable-height all-metal field tripod. .... **$1099.**

Model 2080B—Identical to Model 2080A, but in addition with Super Multi-Coated optics. .... **$1149.**

Packing & shipping on either 8″ model in the 48 states: . **$95.**

Specifications: 10″ Model 2120A—Complete with 10″ f/10 Schmidt-Cassegrain optical tube assembly; fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75″ worm gear motor drive system (115v/60Hz); eyepiece holder (1.25″); diagonal prism; coated MA 25mm eyepiece (1.25″); 8 x 50mm viewfinder; equatorial wedge; variable-height all-metal field tripod. .... **$1379.**

Model 2120B—Identical to Model 2120A, but in addition with Super Multi-Coated optics. .... **$1449.**

Packing & shipping on either 10″ model in the 48 states: **$125.**

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sedimentary, and climatic history. Studies aimed at the existence of life on Mars should be secondary until we have ways to really implement them. — *Graham Ryder, Lunar and Planetary Institute, Houston, Texas*

How Many Rubles to Mars?

How can Russia afford such astronomical expenditures on spacecraft to visit Mars? (See "Mars: The Russians are Going!," October 1993.) I can't understand buying spacecraft when they are unable to supply sufficient food and reasonably modern products for their citizens. Will the United States in effect be financing their mission? — *Ray Akers, Hot Springs, Arkansas*

Billboards in Space

I hope that you take NASA and Space Marketing Concepts to task for the billboards in space project ("New Heights (?) for Advertising," September 1993). This would be a far more fundamental mistake than NASA's handling of the Hubble Space Telescope or Mars Observer missions.

NASA and Space Marketing's reason for undertaking such a project? "There's no law against it." — *Craig Daniels, Florence, Oregon*

— NASA has nothing to do with the billboards-in-space concept.

Don't be so sure that corporations won't pay $30 million to float a billboard in space. Imagine the attention it would garner. And, after all, they wouldn't be paying one cent. The consumers would financially support the whole thing, of course. — *Yvonne Goddess, Rochester, Michigan*

Why Learn Star Names?

I wish to thank ASTRONOMY for publishing Thomas Henry's essay on star names (October 1993). His reasons for learning star names were that they reveal something about a star's location, that they provide a mnemonic, a memory hook, and that backyard astronomers are fascinated by mythological names.

I agree with the second reason. Mnemonics help people to learn and learning is a good thing. However, I disagree with points one and three. What science or information on star locations is contained within mythology? None. — *Milo Rea Gardner, Fair Oaks, California*

Nikons for Astrophotography

I enjoyed "Seeking the Best 35mm Camera" (September 1993). Some clarification is needed regarding the Nikon FM2. Although the camera has no lever to permanently lock up the mirror, you can get around this by using the camera's self-timer. As soon as you release the shutter button, the mirror will lock up. By setting the timer, you can lock up the mirror as long as ten seconds before the shutter opens.

The author stated, "With Nikon, all their lenses, old and new, will fit and focus on every 35mm camera Nikon has ever made." Unfortunately this is not true. Many lenses will not fit the FM2, for example, because the lens hits the camera's meter coupling lever if you try to attach them. The FM2 does not accept any fisheye lenses, for example. — *Pat Maturo, Orange, Connecticut*

— You can latch the lever up out of the way to accommodate old non-AI lenses.

Plaudits for Eyepieces

Thanks for publishing the best guide to eyepieces I've seen so far ("Choosing Eyepieces: A Buyer's Guide," June 1993). I was in the midst of compiling such a listing and was overwhelmed with the details of the models. You've saved me the trouble of continuing! — *Moshe Bain, Sao Paulo, Brazil*

Celestron 5 Test Report

Thank you for your excellent review of our Celestron 5 telescope (October 1993), which confirms our own feelings. I would like to clear up some confusion regarding a couple of points, however. Regarding the radial guider, the C8 model will focus with the C5 but the prism is not far enough into the light cone for satisfactory results. By contrast, the C5 guider model will not work well on the C8 because when the prism is too far into the light cone it causes prism shadowing.

Your reviewer mentioned a slight internal flare when you did prime focus deep-sky photography. We have duplicated this situation and find this occurs generally when the illumination of the guiding eyepiece is turned up too much and the light is reflected off the back lens of the reducer onto the film.

With respect to the tripod, the optional tripod is a Celestron product and not a Vixen product. — *Alan R. Hale, President, Celestron International, Torrance, California* □

ASTRONOMY welcomes suggestions and additional information about articles and astronomy in general. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length and clarity.

Pilgrimage to Palomar

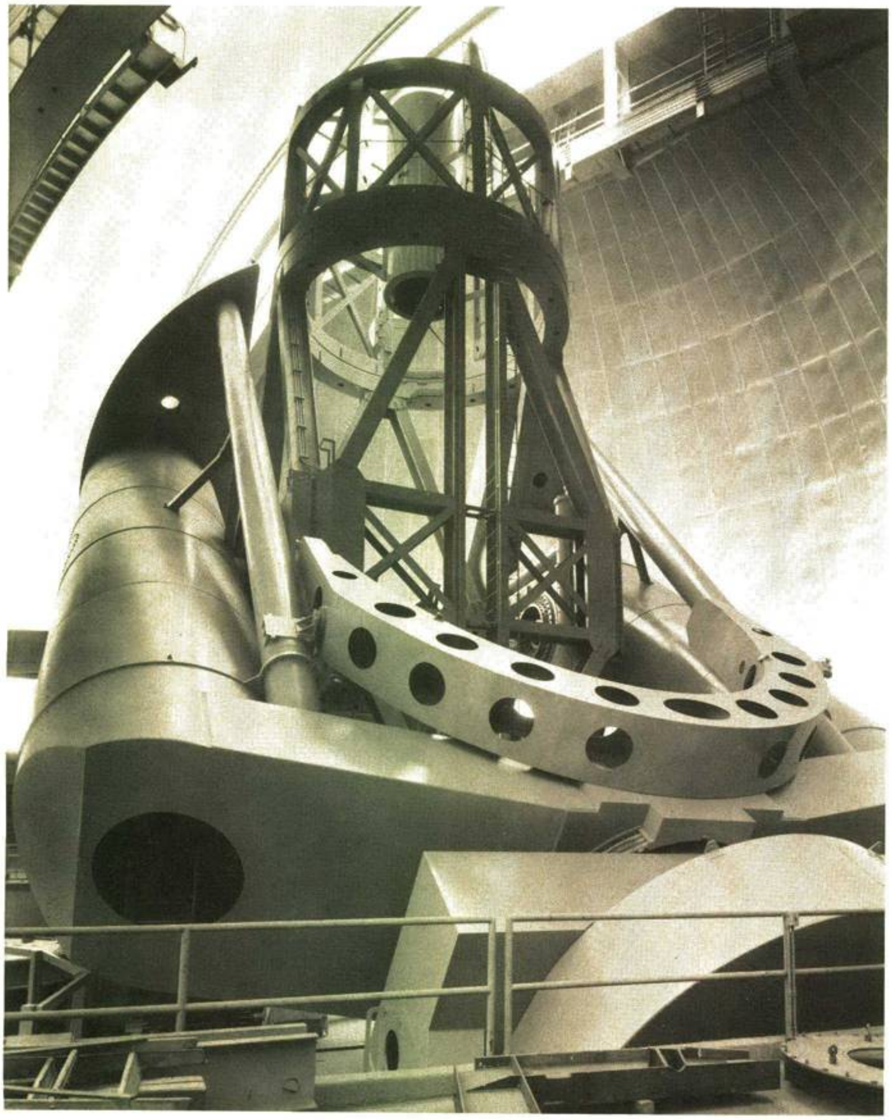
by Norm Looper

> "Make no small plans."
> George Ellery Hale (1868-1938)

It is a charmed Sunday in early July 1991 as my friend Brent and I drive east out of Valley Center toward Palomar Mountain. As we ascend through the foothills, the California live oaks slowly give way to an occasional, beleaguered pine tree. After five years of drought the land looks dry, even though we had plenty of rain this spring.

We are heading to see the 200-inch Hale reflector on the mountain. This is a pilgrimage each of us has made several times, to stand in the presence of the majestic instrument that has done more than any other to expand our view of the universe. Although neither of us is an astronomer, as ardent laymen who follow science, we know something about the telescope on Palomar.

Even as we drive toward this marvelous scientific instrument, the centerpiece of ground-based optical astronomy for almost half a century, it is being eclipsed in light-gathering power by a radically new and larger instrument, the 400-inch Keck telescope on the summit of Mauna Kea in Hawaii. So this trip has a feeling of nostalgia about it too, as if we are saying goodbye to an old friend. This sentiment is probably specious, because for years to come, aided by ever new and more sensitive attachments, Palomar will continue to provide important new information on our tiny place in this numbingly large universe.



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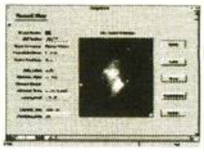

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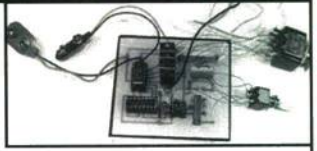

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We are now out of the foothills and climbing the steep, curving grade of the mountain. To our left, from about 3,000 feet, we can see the thick smog that clings to the lower valleys like a pall. When the telescope was placed here in the 1940s, this mountain was a pristine and inaccessible site, with clean mountain air and no encroaching city lights. But now, like Mt. Wilson before it (which also hosts a Hale-built telescope), the approach of civilization, rather than technical obsolescence, may sound the eventual death knell of Palomar Mountain Observatory.

There is a special irony in this, I think, because Palomar Mountain, and astronomy in general, is intended simply to watch the universe, not intrude on it. Meanwhile people seem intent on destroying the habitat of this fine scientific instrument.

The light pollution from swollen Escondido is having a pronounced effect on the sky darkness at Palomar, showing up particularly on long time exposures. Local government has made some attempt to install low-pressure sodium street lights, which emit a filterable monochromatic line of yellow light. However high-pressure sodium and mercury vapor lights still seem to be everywhere.

Some years ago a local politician, a kind of John Wayne character who rode his horse in annual parades, lamented that the ghostly low-pressure sodium lights made citizens look "cadaverous" at night. Certainly a few photographic plates showing the edge of the universe and the beginning of time were simply inadequate compensation for this loss of cosmetic attraction. After all, this is America.

As the grade of the mountain road steepens, I recall a photograph from the 1940s showing the same section of the mountain. Against a backdrop of cleared pines, it showed a 24-wheel trailer slowly but methodically hoisting the 200-inch mirror, all 14 tons of it, up this same grade.

George Ellery Hale, the man who oversaw the 200-inch-telescope project, was a pioneering solar astronomer, hobnobber with the very rich, and formulator of vast undertakings. He built four giant telescopes in his day and helped found the California Institute of Technology. Hale carefully developed his telescope designs so that each was larger than the previous: the Yerkes Observatory (University of Chicago, 1892, a 40-inch refractor), Mount Wilson Observatory (Los Angeles, 60-inch and 100-inch reflectors), and finally Palomar Observatory,

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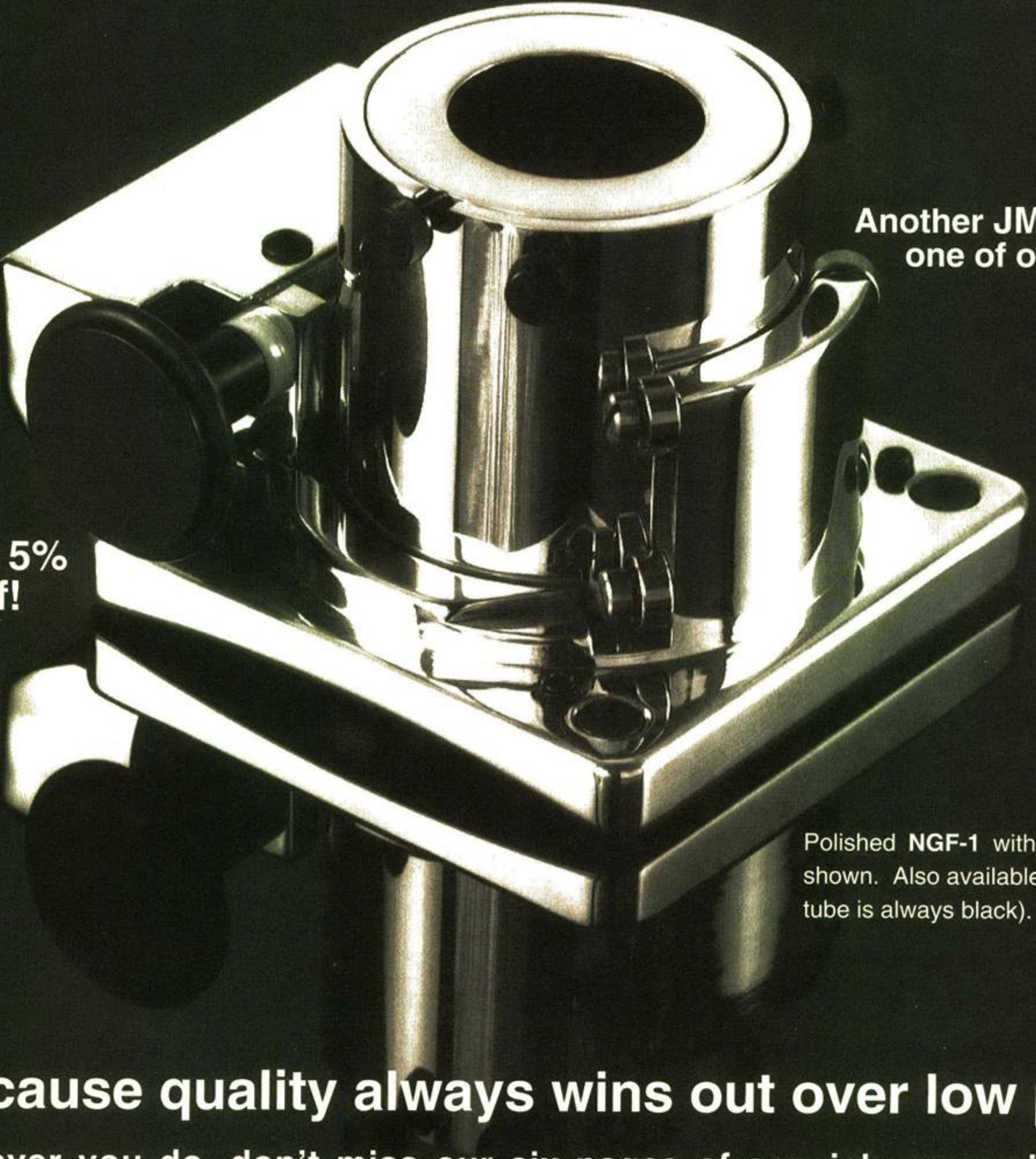

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A friend of the rich, Hale constructed Mt. Wilson Observatory under the auspices of the Carnegie Institution of Washington and Palomar Observatory from funds donated by the Rockefeller Foundation. Work on Palomar began in the mid-1930s, and the scope and dome were completed by late 1941. Work on the 200-inch mirror proceeded more slowly, as opticians were needed for other jobs during the Second World War. The mirror was finished and shipped to Palomar in 1947. Unfortunately Hale didn't live to see his crown jewel of optical astronomy, having died in 1938.

Driving along a last winding ridge, buried in pines (many of them ominously brown from drought or blight), Brent and I come to the Palomar Observatory parking lot. As I get out of the car, I lather sun block on my pale skin. The stucco exterior of the Observatory's museum has been touched up since I was last here, and the facility looks well kept, if Spartan. An excellent video hosted by British astronomer Patrick Moore plays continuously in the cool interior of the museum.

Since first light in January 1948, technological upgrades have helped make the 200-inch telescope ever more sensitive. More sensitive films, spectrographs, and charge coupled devices are just a few of the advances that keep the 200-inch at the forefront of observational astronomy.

The telescope's domed housing looks resplendent and, as we enter the hushed visitors gallery, we are awed yet again by the 500-ton trussed and yoked frame of this incredible device. This is a machine that lives only at night, overseen by a community of often lonely and unbelievably patient men and women.

As Brent and I drive away from Palomar, a thunderhead over the mountain rumbles. It seems fitting punctuation to this visit, a reminder that the 200-inch is no longer the pre-eminent telescope on the planet.

I first saw Palomar with my parents as a boy, and now feel vulnerable at this parting. I don't look back. I'm afraid that the sight of the marvelous optical machine behind me could cause me to lose a piece of my childhood, just as it helped end our cosmological childhood. The 200-inch Hale telescope expanded our view of the cosmos immeasurably, placing us in that adult perplexity where we come to know ever more accurately, but cannot fully comprehend what it means to be mortal. ☐

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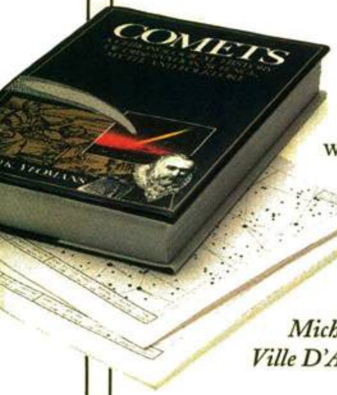

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Below - Captured Comet Shoemaker-Levy (1993e) impacting Jupiter, July 1994.

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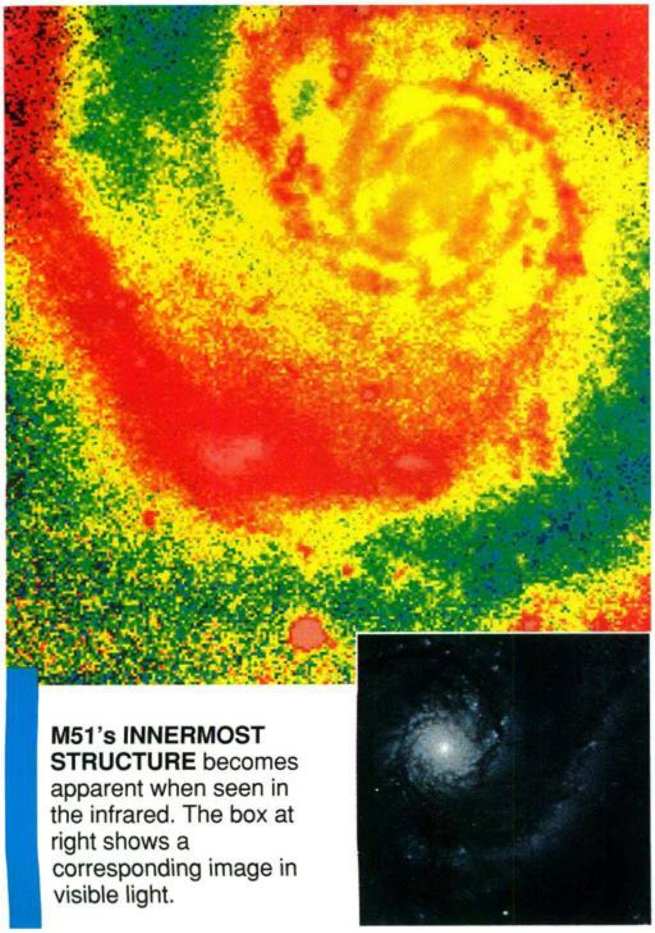
Seeing Inside M51

New observations show that the spiral arms of M51, the Whirlpool Galaxy, extend much closer to the galaxy's center than was previously known. Infrared images obtained by Dennis Zaritsky of Carnegie Observatories, Marcia Rieke of the University of Arizona, and Hans-Walter Rix of the Institute for Advanced Study in Princeton, New Jersey, trace the arms for three continuous revolutions, twice as far as the arms appear in visible-light images.

The discovery poses a strong challenge to theoretical models of spiral structure in galaxies. Previous observations showed that almost all grand-design spirals — ones like M51 with long, symmetric arms — have central bars or close companion galaxies. The gravity of the bar or the companion concentrates the galaxy's gas and stars in spiral "density waves." (See "What Puts the Spiral in Spiral Galaxies," September 1993.)

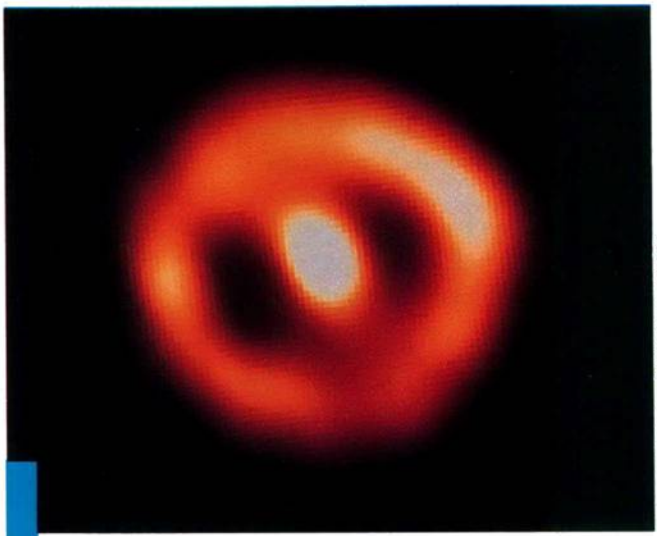
The gravity of M51's neighboring galaxy, NGC 5195, may produce the outer spiral arms of the Whirlpool Galaxy but it is too weak to trigger the inner arms. Zaritsky and his colleagues suggest that the combination of the gravities of the central bar and the companion galaxy may generate the arm structure. — *Ray Jayawardhana*



Hans-Walter Rix

Canada-France-Hawaii Telescope

M51's INNERMOST STRUCTURE becomes apparent when seen in the infrared. The box at right shows a corresponding image in visible light.



Francesco Paresce, ESA/STScI and NASA

THE GAS SHELL EJECTED by Nova Cygni 1992 remains clumpy 467 days after the star's explosion. Twin jets of gas erupting from the explosion may have caused the bar in the middle of the ring.

Hubble Sees Nova's Gas Shell

Nova Cygni 1992 erupted in February 1992 as gas from a star in a binary system triggered a thermonuclear explosion on the surface of its white dwarf companion. Usually it takes about five years for the gas shell expelled by the nova to expand enough for ground-based telescopes to glimpse it. But astronomers using the Faint Object Camera on the Hubble Space Telescope have imaged the shell just 15 months after its ejection.

The image reveals the shell is now 37 billion miles across or about five times the size of the solar system. By measuring the shell's diameter and its expansion speed, astronomers calculate the nova lies 10,430 light-years from the Sun, a bit farther than the original estimate of 7,300 to 9,500 light-years (see "Neon Nova," July 1993).

By the time ground-based telescopes can resolve the shell, the gas will have encountered other matter around the star, causing the shell to deform and become chemically contaminated. "The Hubble observations provide a unique opportunity to study the 'pristine' envelope of gas ejected by the explosion," says Francesco Paresce of the European Space Agency and the Space Telescope Science Institute.

Dark Matter in MACHOs

Astronomers calculate that roughly 90 percent of our Galaxy's mass is dark matter. Emitting little or no radiation, it can be detected only through the effect of its gravity. Now researchers from America, Australia, and France report the first evidence for dark matter in a form called Massive Compact Halo Objects, or MACHOs for short.

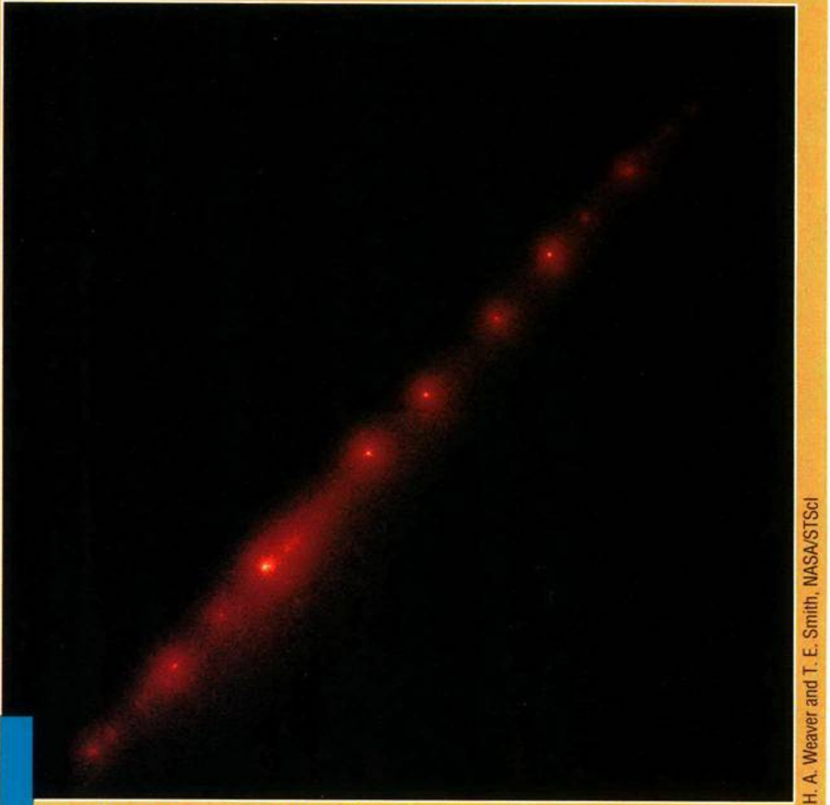
MACHOs likely are either Jupiter-sized planets or brown dwarfs — objects not quite massive enough to ignite nuclear reactions in their cores to become stars. They might lie in the vast halo that surrounds the Galaxy.

The researchers have been searching for microlensing events. Such an event occurs when a MACHO crosses the line of sight between a telescope on Earth and a star in a distant galaxy. The MACHO's gravity acts as a lens, causing the star to brighten for a month or two. The event is short-lived because the star, the MACHO, and Earth all move relative to one another.

(continued on page 20)

COMET CRASH NEWS

Since the September 1993 issue, ASTRONOMY has brought readers up-to-date on the impending impact of Comet Shoemaker-Levy 9 with Jupiter this coming July. As part of our continuing coverage here's a summary (adapted from a report prepared by Jay Melosh of the Lunar and Planetary Lab) of major findings discussed at a comet workshop held August 23 and 24 in Tucson:



H. A. Weaver and T. E. Smith, NASA/STScI

AN IMAGE FROM HUBBLE revealed 20 nuclei in Shoemaker-Levy. Images from the repaired Hubble in 1994 should resolve more detail and settle just how large these fragments are. Such information is necessary to predict what effect the fragments' impact will have on Jupiter.

- Appearances notwithstanding, the multiple fragments of the comet are not traveling one behind the other in a single-file line. Rather, the line of fragments is oriented almost perpendicular to the direction of flight.
- Images taken with the Hubble Space Telescope place an upper limit of five kilometers on the size of the largest of the comet's 20 known nuclei. However, the Lunar and Planetary Lab's Jim Scotti and Jay Melosh estimate that the original comet was no more than two km across and therefore the fragments we now see must be much smaller. The weak tidal forces from Jupiter that broke the comet apart in 1992 mean the original comet must have been a very loosely held aggregate of dust and ice.
- When Hubble's images were taken this past spring, the comet was shining only by sunlight reflected off dust and showed no signs of having any gas. This prompted some conference participants to wonder if Shoemaker-Levy 9 is actually an asteroid. But those familiar with the behavior of comets far from the Sun pointed out that it is normal for a comet at the distance of Jupiter to show no signs of gas emissions.
- Kevin Zahnle of JPL estimated that comet fragments a kilometer across will explode in a fireball about 200 km below the cloudtops of Jupiter, with temperatures in the shock wave ahead of the fireball reaching 30,000° Celsius. Initially, the hot fireball will be hidden from view but will become visible from space when it rises into the atmosphere a minute after the impact. However, as of August, scientists had not yet had enough time on supercomputers to produce complete models of what will happen when Shoemaker-Levy hits Jupiter.
- Andrew Ingersoll of Caltech suggested that the heat of an impact fireball from a two km object might create a circular high-pressure vortex some 2,000 km across in the Jovian atmosphere. However, computer simulations performed by Tim Dowling showed no long-lived spots created by the impacts.
- Large quantities of dust accompany the comet and are visible in photographs as wings extending from both ends of the chain of nuclei. The dust may be coming from meter-sized comet bits spread out beyond the ends of the comet chain.
- Alex Dessler of Rice University calculated that dust particles from the comet will break down and become charged as they pass through the magnetosphere of the planet and may even cause the magnetosphere to become visible. Dessler suggested wide-angle photos (2° field) of Jupiter taken with Schmidt cameras might show this effect.
- Jay Melosh and Paul Schenk of the Lunar and Planetary Lab pointed to several chains of craters on Jupiter's moon Callisto as evidence for earlier impacts with comets similar to Shoemaker-Levy.
- Jupiter will be 60 pixels across the camera frame of the Jupiter-bound Galileo spacecraft at the time of impacts July 18 to 23. The impact sites on the nightside of Jupiter will occupy only one pixel. Nevertheless, Galileo scientists expect to obtain good data from Galileo in both visible and infrared light. Galileo should also pick up radio emissions from the interaction of the comet with Jupiter's powerful magnetic fields.
- Voyager 2 will look down directly onto the impact sites but from a great distance near the edge of the solar system. Jupiter will be only two pixels across on its camera frame but Voyager might still be able to detect changes in brightness from explosions in the atmosphere.
- Finally, Gene Shoemaker, one of the discoverers of the comet, pointed out that Shoemaker-Levy 9 may not be unique. He estimates that at any given time a comet of at least two km across is in orbit about Jupiter, and that it's likely that Jupiter captures a comet about once a century.

For more information about Shoemaker-Levy 9's impact, see the September, October, and December 1993 issues of ASTRONOMY.

For the past year, the American and Australian researchers have monitored about 3.3 million stars in the Large Magellanic Cloud. During this time they detected one probable microlensing event, in which the star brightened by seven times and then returned to normal over a two-month period. The French astronomers found two microlensing events in which the stars tripled in brightness. With just three observed events, however, astronomers can't yet conclude how many MACHOs exist or how much of the Galaxy's dark matter may be MACHOs.

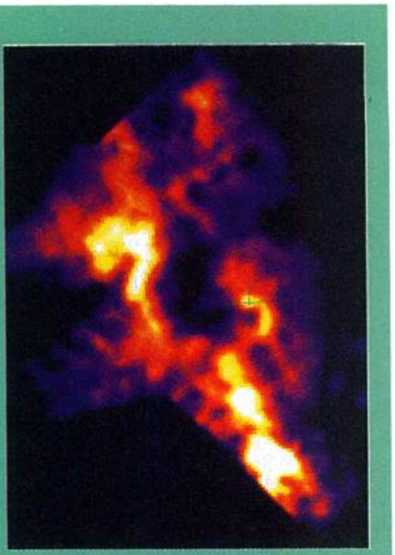
How About a Gray Hole?

A supernova explosion is the death knell in the life of most massive stars. But the core of the exploded star remains as a neutron star or a black hole, depending on mass. Or so standard theory says. Now astronomer Kenneth Brecher of Boston University proposes an object intermediate between the two, one he calls a gray hole.

These gray holes are actually neutron stars compact enough to trap most but not all of their emitted radiation. And the gray holes could be masquerading as black holes in some X-ray binary systems.

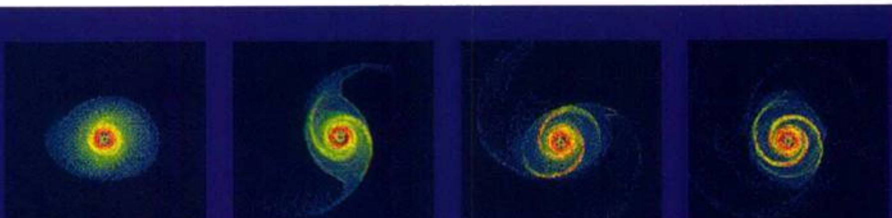
Astronomers know of some half-dozen binary systems in which one component seems to have a mass more than three times the Sun's mass but which can't be seen optically. Traditionally, astronomers thought neutron stars had to have masses less than this, but recent models of dense matter suggest that isn't necessarily so. Apparently objects five to ten times the mass of the Sun can collapse and still avoid becoming a black-hole.

The general theory of relativity says that some radiation leaving such an object could be trapped in a "photon sphere" where light orbits the object. The intense gravity of the collapsed object also causes emerging radiation to lose energy. Brecher found that the loss of energy combined with the partial trapping of photons would allow as little as 0.4 percent of the radiation to leave the object. The resulting "gray hole" would be both massive and dark and thus would mimic the observed properties of the black hole candidates in X-ray binaries.



W. Dent/Joint Astronomy Centre

WARM DUST DOMINATES OUR GALAXY'S CENTER when you view it at submillimeter wavelengths. This false-color image shows the central 50 light-years of the Galaxy (white represents the strongest emission, purple and black the weakest). The Galaxy's plane runs from upper left to lower right and Sagittarius A*, the precise center of the Galaxy, is marked by the cross just right of center. Most of the submillimeter emission comes from warm dust in the giant molecular clouds that surround the core. Curving away from Sagittarius A* is an arc of emission that forms part of a compact dusty ring. Just to the east (left) of Sagittarius A* lies an empty hole thought to be caused by a supernova explosion that compressed, heated, and pushed back most of the surrounding clouds.



WHEN TWO GALAXIES COLLIDE, intricate spiral patterns can arise. In this supercomputer simulation developed by Jordan Burkey, William Keel, and Gene Byrd of the University of Alabama and Sethanne Howard of Universities Space Research Association, a disk galaxy with twice as much mass as its companion feels the tidal effects of a close encounter. At closest approach, the centers of the objects are separated by one diameter of the disk galaxy. Reading from left to right, you can see spiral structure develop and evolve over millions of years.

ORFEUS Flies High

For six days in mid-September, the second largest space telescope ever launched floated free of the space shuttle and examined the ultraviolet sky. ORFEUS, the Orbital Retrievable Far and Extreme Ultraviolet Spectrometer, is a one-meter reflector designed to fly several times into space while attached to a German-made free-flying platform called SPAS, the Shuttle Pallet Satellite. ORFEUS can split the far-ultraviolet light of stars into spectra with up to 20 times the detail of previous space telescopes such as the shuttle-borne Hopkins Ultraviolet Telescope and the Extreme Ultraviolet Explorer satellite.

During its first flight in September, ORFEUS took high-resolution spectra of nearly three dozen targets, mostly stars, to learn more about how the surface activity of nearby stars compares with activity on the Sun. ORFEUS also looked at a BL Lac object, a type of distant active galaxy, looking for information not about the object itself but about the material floating in space

NASA

RISING FROM THE PAYLOAD BAY last September, the German/American ORFEUS ultraviolet telescope prepares to fly free of the shuttle for a six-day mission.

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between Earth and the BL Lac galaxy. Said project scientist Stuart Bowyer of the University of California, "We had a tightly packed observing schedule. But in the end we got everything we set out to get." ORFEUS is scheduled to fly again in 1995.

Refining the Distance to the Hyades

Knowing the distance to the Hyades star cluster in the constellation Taurus is an important stepping stone in astronomers' efforts to determine the distances to galaxies. If the distance to the Hyades is in error, our vision of the universe is accordingly too big or too small. As important as knowing the distance to this cluster is, astronomers have had trouble pinning this number down precisely.

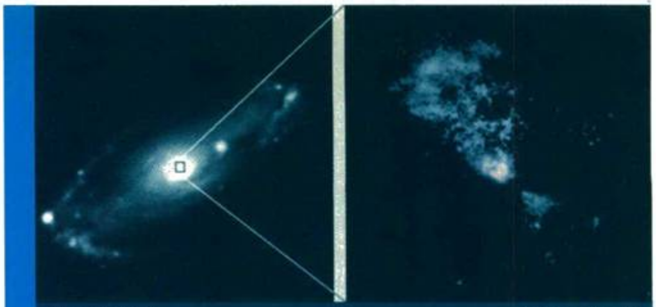
Different methods have yielded distances for the Hyades that range from 141 to 156 light-years, an uncertainty of 10 percent. To improve our knowledge of the Hyades distance, Volker Weidemann of the Universität Kiel in Germany, looked at five white dwarfs in the cluster. Using the stars' spectra to measure their temperatures and radii, Weidemann could determine how bright the stars really are. To find their distance, he then compared this brightness with how bright they appear to Earth observers. His result of 152 light-years supports the larger distance given above, but it still has an uncertainty of five percent. The final solution to the Hyades distance problem may be near: Measurements made by the Hipparcos satellite should determine the distance.

Active Galaxies Produce Background of X Rays

The sky at night appears an endless dark expanse sprinkled with pinpoint stars — at least to the human eye. But to X-ray detectors on spacecraft, the sky glows brilliantly in every direction. Now researchers have pinned this X-ray background on the combined radiation from countless active galaxies in the distant reaches of the universe.

In the late 1970s, the Einstein X-ray satellite returned data that showed active galaxies were both numerous enough and bright enough to explain the background of low-energy X rays. But astronomers didn't think that active galaxies could explain the high-energy X-ray background.

Now astronomers Julian Krolik of Johns Hopkins University in Baltimore, Maryland, and Andrzej Zdziarski and Piotr Zycki of the Copernicus Center in Warsaw, Poland, have shown that they can. Drawing on new data from the Compton Gamma Ray Observatory and the Japanese Ginga satellite, the researchers report that the spectra of active galaxies do match the background at high energies. The team then used new statistical studies to show that the universe was populated with huge numbers of active galaxies just a few billion years after the Big Bang and that the total X-ray output from these active galaxies closely matches the brightness of the X-ray background we see today.



Allan Sandage/
Carnegie Observatories

Andrew Wilson/
Space Telescope Science Institute

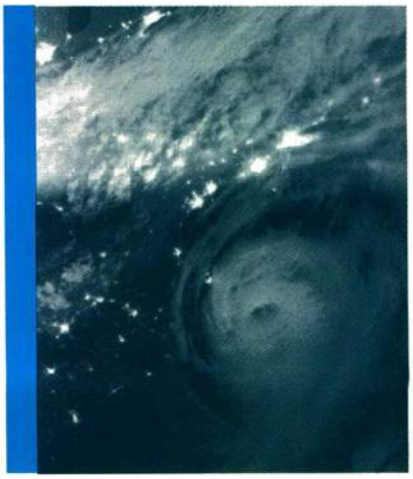
A GALACTIC LIGHTHOUSE: Astronomers suspect a disk of gas is accreting or slowly spinning into a supermassive black hole in the core of the spiral galaxy NGC 5728 in the constellation Libra. A larger disk of gas surrounds the black hole and the accretion disk and blocks our view of these objects. This disk shapes light emitted by the accretion disk into the two conical beams seen in this Hubble Space Telescope image.

Small Explorer Satellites Approved

In late September, NASA selected four new Small Explorer satellites from a list of 51 candidate missions. Previous missions include the Solar, Anomalous, and Magnetospheric Explorer (launched in July 1992), the Fast Auroral Snapshot Explorer (set for launch in August 1994), and the Submillimeter Wave Astronomy Satellite (to be launched in June 1995). Expected to fly in 1997 or 1998, the four new missions are

- the Joint Ultraviolet Night Sky Observer (a spectroscopic survey of the ultraviolet sky),
- the Positron Electron Magnetic Spectrometer (a measure of the ratio of electrons to anti-electrons, also called positrons, in cosmic rays),
- the Transitional Region and Coronal Explorer (a study of the connection between the Sun's magnetic fields and outer atmosphere),
- and the Wide-Field Infrared Explorer (an infrared look at the evolution of galaxies).

An aircraft-launched Pegasus rocket booster will propel each of the satellites into space, and each Small Explorer mission will cost about $35 million.



Hank Brandli

EMILY BY MOONLIGHT appears in this image from a Defense Department weather satellite as the hurricane moved up the East Coast on August 31. A Full Moon illuminated the hurricane as well as clouds from a cold front moving down from the north. The lights of New York form the large glow north of the hurricane.

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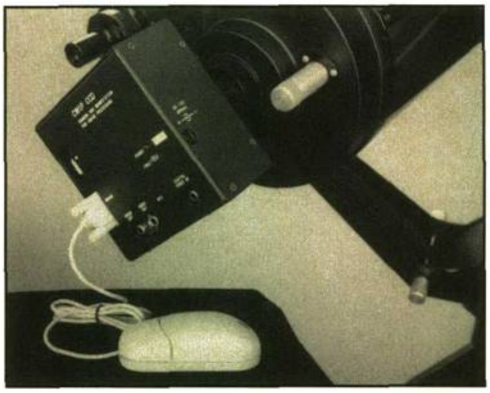

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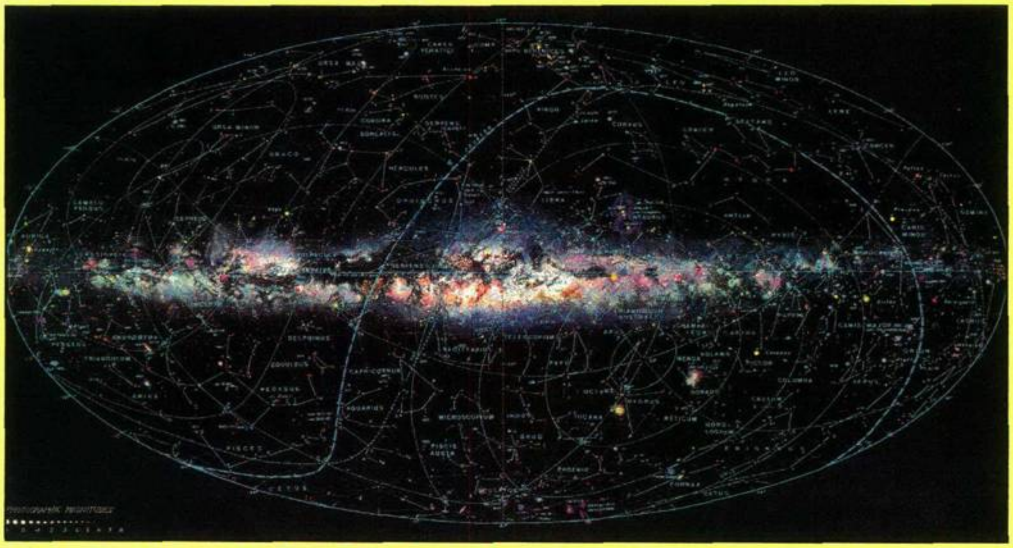

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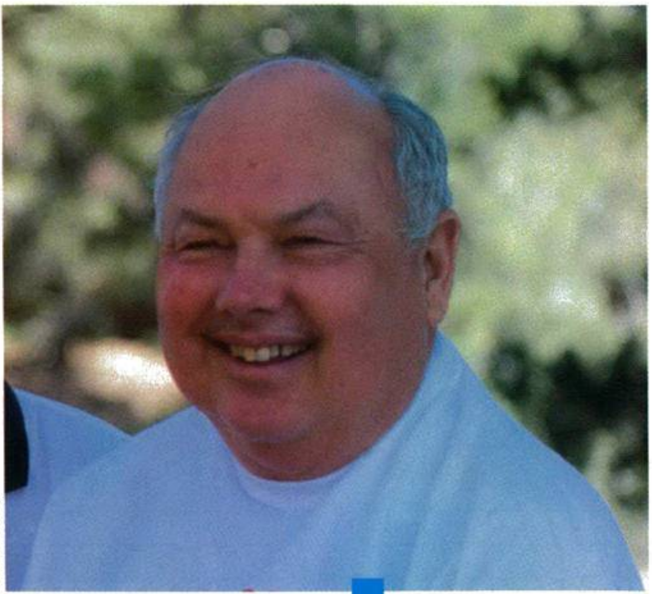
AMATEUR NEWS

CLIFFORD W. HOLMES (1929 – 1993)



David H. Levy

Amateur astronomy lost one of its brightest stars last September 8, with the passing of Clifford W. Holmes. Widely recognized in amateur astronomy, Cliff was awarded the Western Amateur Astronomer's G. Bruce Blair Award, given to amateurs for significant contributions to the hobby.

Cliff is best known for establishing and running the Riverside Telescope Makers' Conference. Initiated in 1969, the conference started relatively small, drawing just over 100 participants in its early years at the Riverside City College. With the growth in attendance and the desire to *use* the telescopes crafted by participants, the conference moved first to a mountain camp near Idyllwild and later to its current home at Camp Oakes near Big Bear, California. Cliff guided the conference to its present size and status — typically 1,500 people come annually to hear talks on telescope making and observing and to see the latest in homemade and commercial equipment. Everyone will remember Cliff's trademark yodel initiating the Saturday night festivities.

CLIFF HOLMES established and for many years managed one of the largest amateur astronomy gatherings, the Riverside Telescope Makers' Conference.

Cliff loved astronomy and made it his life. During the day he worked for Hostess Snack Foods, driving a delivery truck. He liked to joke that he was just a Twinkie salesman. But when that Twinkie salesman retired, he went out and earned a California special teaching credential and took up residence as the astronomy and planetarium instructor at Riverside City College. He touched the lives of hundreds of students, guiding some toward a career in the field.

Cliff's energy, happiness, dedication, and enthusiasm served as an example for the rest of us. He will be missed.
— *Steve Edberg*

ASTRONOMY: Alan Dyer

THE HILLS WERE ALIVE with the sounds of observers as 350 amateur astronomers, the biggest crowd yet, filled the campsite at Starfest '93, Canada's largest amateur astronomy gathering. Held August 20 and 21 near Mount Forest, Ontario, Starfest attracted amateurs from around the Great Lakes area for two nights of excellent observing. Special attractions this year included a Friday afternoon workshop on CCD imaging and an astrophotography exhibit and contest.

Network News Goes Electronic

ASTRONOMY magazine's newsletter for astronomy clubs is now available electronically through the CompuServe on-line information service. Formerly printed and distributed free via mail to club officers, Astronomy *Network News* is now published electronically and uploaded to CompuServe's Astronomy Forum every two months as a service to astronomy clubs. Club officers are free to download the files and distribute them to their members either in print form or via their own local or regional computer bulletin boards.

Each issue contains ideas to help clubs provide better services for their members and news from clubs of their accomplishments and innovative programs, as well as discussions of issues clubs have in common — how to raise funds, attract new members, and publish an interesting newsletter, among others.

The current issue can usually be found in the New Uploads section of the Astronomy Forum Library. Back issues are in the General section of the Library.

If you are not familiar with CompuServe, you can call their customer service line at (800) 848-8990 for more information. Monthly and connect charges apply. You can reach *Network News* editor Tom Gill electronically on CompuServe at address 72000,2704 (or via Internet at 72000.2704 @compuserve.com). ☐

ASTRONOMY: Alan Dyer

A RECORD CROWD OF 700 enjoyed the Midwest's biggest star party, Astrofest '93. Organized by the Chicago Astronomical Society, the 1993 Astrofest featured the biggest swap meet in the star party's history, with dozens of vendors offering bargains on astronomical equipment. The campsite near Kankakee, Illinois, was graced with clear skies on the first night, Friday, September 10, but was clouded out the next night.

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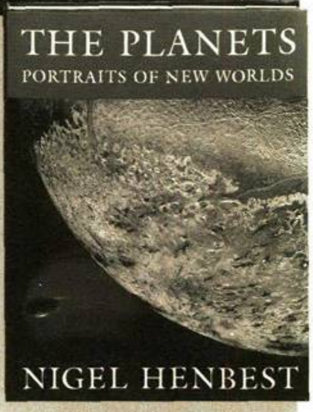

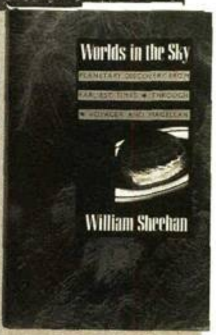

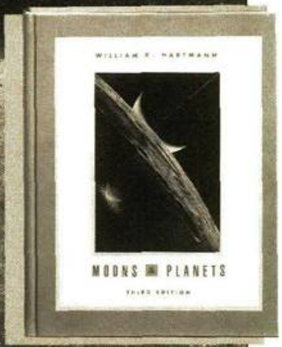

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Imagine yourself floating in space, watching the universe come to life in the Big . . .

BANG.

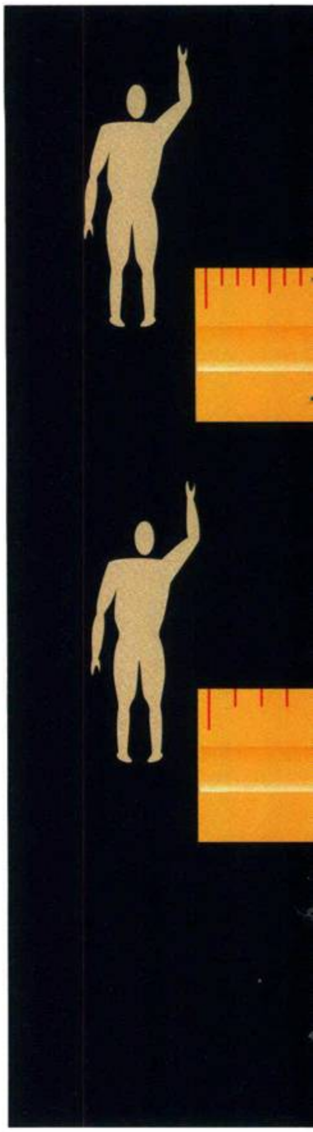
A blinding flash suddenly errupts out of an immense black void. Seconds later clouds of outrushing debris engulf you.

It's a powerful vision, but not an accurate one. Because before the universe was born, there was no space to float in, no perspective from which to view the Big Bang.

You don't need to perform strenuous mental gymnastics to understand the Big Bang. All you need to do is ask the right questions. That's what our readers have done, and we've collected ten of the best. We hope the answers provide you with fresh insights into the nature of this remarkable universe.

Everything You Wanted to Know About the Big Bang

by Richard Talcott



If the universe was created in a Big Bang, why doesn't the cosmic background radiation come from one point in the sky?

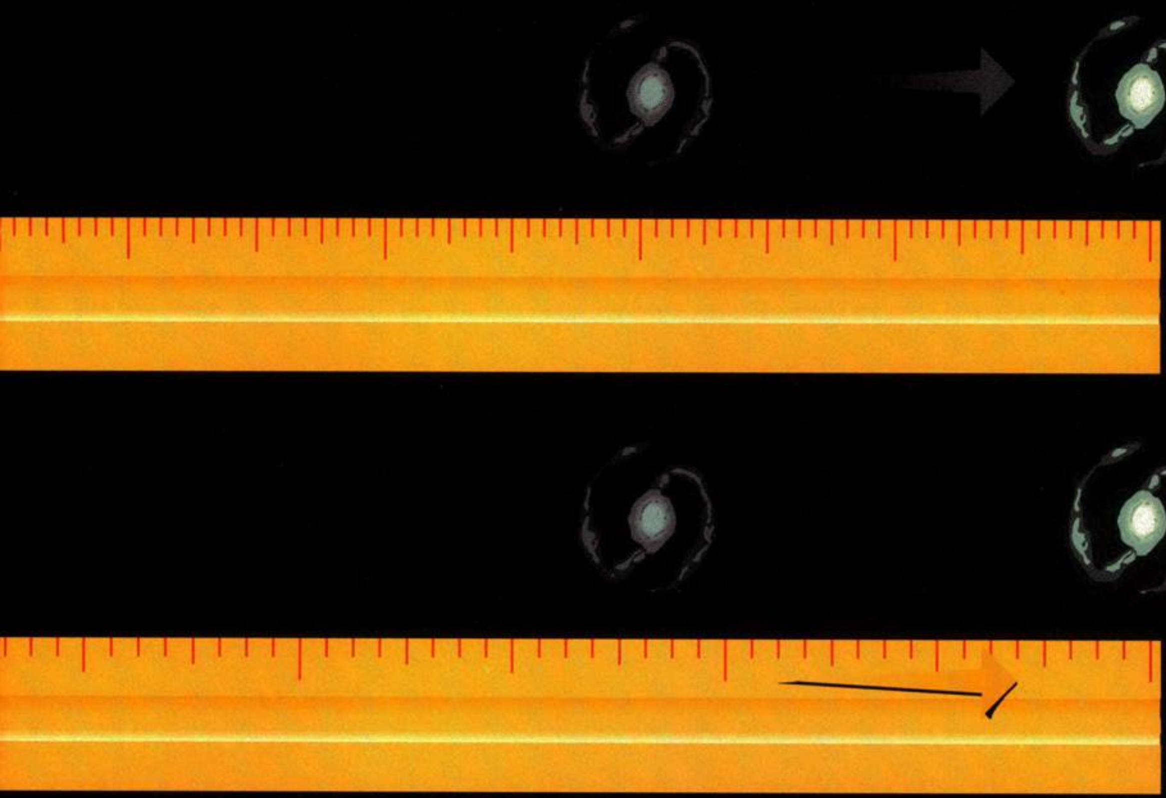
For the same reason that you couldn't have seen the Big Bang from the outside. The Big Bang did not occur at some point in pre-existing space we can now turn our telescopes toward. Rather the entire cosmos, including space and time themselves, originated with the Big Bang. There was no "outside" in which to stand and watch.

The cosmic background radiation is light that dates from a few hundred thousand years after the Big Bang. Before that time, the universe was a seething cauldron of energetic subatomic particles and photons of light. The photons could travel only short distances before interacting with one variety of these subatomic particle, free electrons. But when the temperature of the expanding universe fell to about 5,000 kelvins, electrons combined with atomic nuclei to form atoms. With few free electrons left to interact with, photons could travel unimpeded and the universe became transparent to light.

These photons literally filled the universe then and still do now, which is why the background radiation comes from every direction and not from one point. But in the roughly 15 billion years since the universe became transparent to light, the universe's expansion has cooled this radiation from 5,000 kelvins to a frigid 2.73 kelvins (–454.76° F).

Is space expanding or are galaxies moving apart?

This is a tricky question with no definite answer. At first the question seems little more than a matter of semantics. After all, does it *matter* whether a distant galaxy cluster is speeding away from us through



Do Galaxies Move or Does Space Expand?

When astronomers look at a distant galaxy, it appears to be moving away from us. Is this because space, represented by the rulers, remains constant and the galaxy moves through it (top) or because space itself expands, taking the galaxy along for the ride (bottom)?

space or just riding along as space itself expands? In some instances, it does. Few people would equate walking through a large airport with standing on a moving walkway. But in the first instance you are powering the move through the airport while in the second case the airport (walkway) takes you along for the ride. And even though each method gets you to the same destination, the amount of energy you expend shows that the two are not equivalent.

A large majority of astronomers would agree that space itself is expanding. Einstein's theory of general relativity — the theoretical backbone for most cosmological theories — defines the geometry of spacetime and how it expands over time.

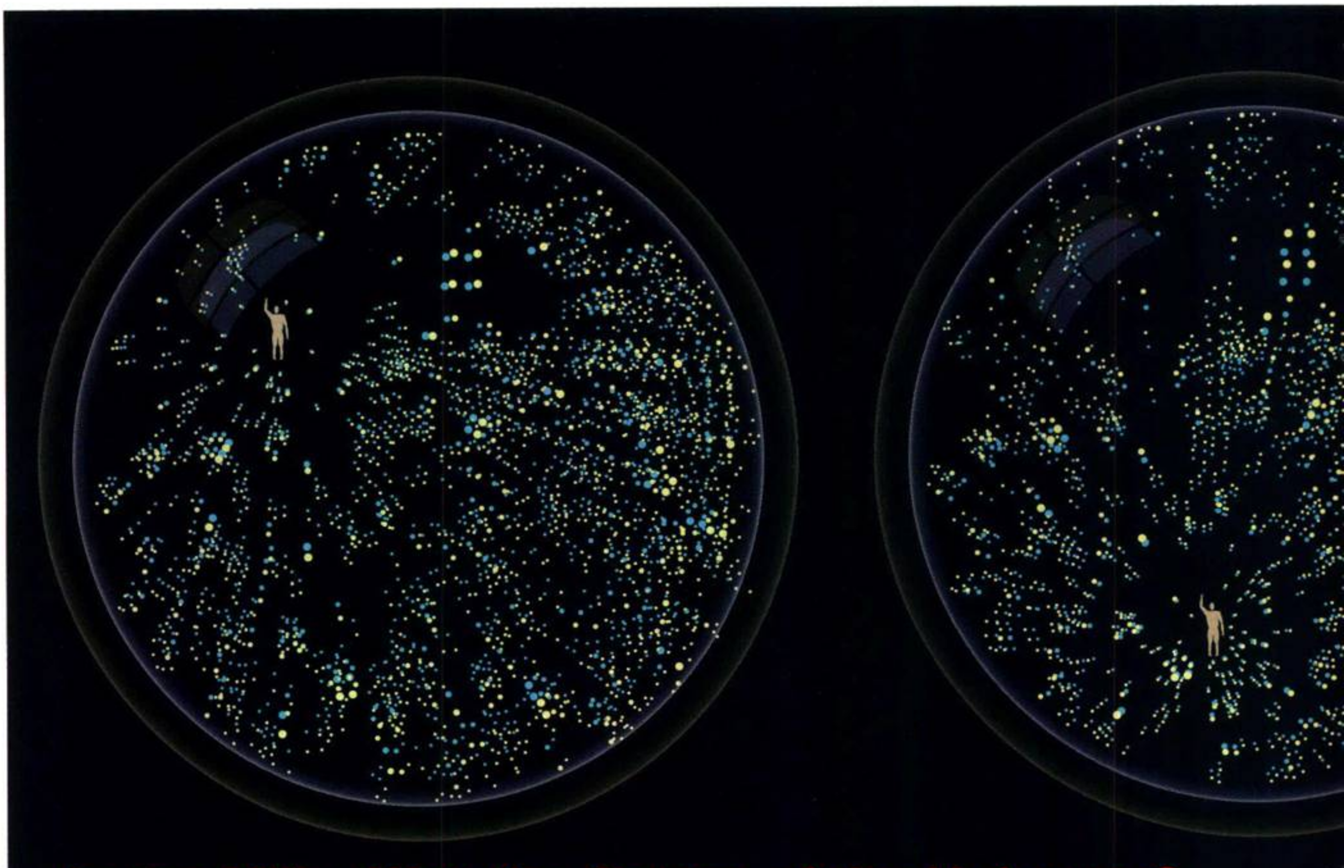
Some people argue that if space expands, then everything in it should expand too, including the rulers you use to measure distance. Then you would never be able to detect the expansion in the first place because the ruler would increase in size at the same rate as the expansion you wanted to measure!

To see why this isn't so, imagine gluing several coins to a balloon and then blowing it up. The expanding balloon represents the expansion of space and the coins represent galaxy clusters. As the balloon inflates, the coins go along for the ride, taking part in the expansion of the balloon but not themselves expanding. Molecular forces hold the coins together, keeping them from expanding. In the same way, gravity holds the galaxy clusters together so they don't expand.

How do astronomers know how old and how big the universe is?

They don't, precisely. But astronomers have developed several ingenious methods for getting at the age of the universe, which seems to be between 10 billion and 20 billion years old.

One estimate comes from what's called the "Hubble age," an age derived from the expansion of the universe. In the 1920s, American astronomer Edwin Hubble observed scores of distant galaxies and discovered two remarkable features: All the galaxies appear to be moving away from Earth, and the farther away the galaxy is, the faster it recedes. Hubble's discovery paved the way for measuring the universe's age —



Is the Milky Way the Center of the Universe?

In an expanding universe, all observers see themselves as the center of expansion. The blue dots represent galaxy clusters at some time in the past and the yellow ones, which are farther apart, the same clusters in the present. Although each view starts with the same distribution of clusters and experiences the same rate of expansion, both observers see more distant clusters receding faster.

figure out how fast the universe is expanding and run the video in reverse back to the time when the expansion began.

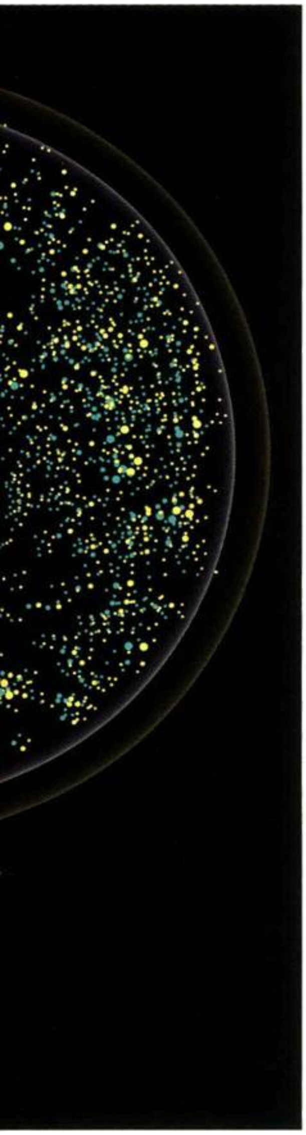
The technique is the same you would use to calculate how long it takes to drive from point A to point B: Take the distance between the points and divide by the speed of your car. In the universe's equivalent, astronomers measure the distances to many galaxies, divide by how fast they move away from Earth, and then average the results. In theory, the technique works great. In practice, measuring the distances to galaxies is fraught with uncertainty, making the age derived from the results debatable.

Some astronomers measure the expansion rate as 15 kilometers per second per million light-years; others find 30. (An expansion rate of 15 means that a galaxy 10 million light-years away recedes at 150 km/sec while a galaxy 100 million light-years away speeds along at 1,500 km/sec.) The inverse of these expansion rates yields a Hubble age between 10 billion and 20 billion years.

The Hubble age measures how old the universe would be if it contained no matter. But you and I offer living proof that the universe is not empty. The gravity of all the objects in the universe slows down the expansion, so the expansion must have moved faster in the past. This in turn means that the universe didn't have to expand for as long to reach its present state, so the Hubble age sets an upper limit to the actual age of the universe.

If the universe is at the critical density — having just enough mass to halt the expansion in the distant future but not enough to cause the universe to contract again — then the real age of the universe must be two-thirds the Hubble age. Many cosmologists think that's precisely how old the universe is. Depending on which expansion rate you want to believe, that makes the universe 7 billion or 14 billion years old. Other cosmologists argue that the density of the universe is significantly less than the critical density, which would make the universe closer to the Hubble age. The age debate continues among cosmologists and between cosmologists and stellar astronomers, who argue that the oldest stars in our Galaxy are more ancient than the cosmologists' universe (see "The Age Paradox," June 1993).

Sizing up the universe is even more difficult than finding its age. The most distant objects we see are quasars, which appear to lie 9 billion to 18 billion light-years from Earth, again depending on how fast the universe is expanding. To find the size of the universe,



astronomers must estimate how much the universe expanded between the Big Bang and the birth of quasars 1 billion to 2 billion years later.

If during this time the expansion rate changed only because gravity slowed it down, then the universe's size is just a bit more than the distance to the farthest quasars. That would make the universe approximately 10 billion to 20 billion light-years in radius.

But many, if not most, astronomers think something much different happened right after the Big Bang. In 1981 Massachusetts Institute of Technology physicist Alan Guth proposed a model that attempted to explain two conundrums of big-bang cosmology: why the universe started off exactly uniform everywhere and why it is so near its critical density.

His "inflationary" model and subsequent refinements to it suggest that the universe expanded by some one thousand billion billion billion times (10^{30}, or a 1 followed by 30 zeros) during an exceedingly brief interval just after the Big Bang. If this scenario is correct, the radius of the universe must be vastly larger than 10 or 20 billion light-years. In effect most of the universe is out of sight, beyond the horizon denoted by the cosmic background. As time goes on, our horizon will expand and we'll start to see more of the rest of the universe.

If all galaxies move away from us, doesn't that make the Milky Way the center of the universe?

No. This is another misconception that comes from thinking of the Big Bang as an explosion occurring before your eyes. Instead of thinking of yourself as an outside observer, imagine yourself swept up in the Big Bang.

A good way to envision this is with an analogy. Picture a magical balloon made of so much rubber that it can be blown up as much as you want. Now imagine a two-dimensional creature living on the surface of the balloon. All it can see is what lies on the balloon's two-dimensional surface, which is the creature's entire universe. As the balloon inflates, its neighbors move farther away as the rubber between them stretches. And the more distant the neighbors, the more rubber there is to stretch, so they appear to move away from each other faster.

The two-dimensional creatures of our analogy are the galaxies in our universe. As the universe expands (the balloon inflates), all the galaxies (creatures) move away from each other, and the more distant they are, the faster they move. Finally, the universe (the surface of the balloon) has no center.

How could galaxies form if during the Big Bang everything moved away from everything else?

Gravity is both strong and pervasive. As Isaac Newton showed over 300 years ago, every particle with mass in the universe attracts every other particle, whether they move away from each other or not. In the chaotic aftermath of the Big Bang, incredible numbers of elementary particles interacted, creating pockets of slightly higher density. These formed the seeds for the later development of galaxy clusters.

Despite gravity's key role in organizing the universe, the exact mechanism by which it forged the galaxies and galaxy clusters we see today remains elusive. In fact it's one of the major mysteries of modern cosmology. Measurements from the Cosmic Background Explorer satellite show that the seeds for galaxy formation existed by the time the cosmic background radiation began its journey through space (see "COBE's Big Bang," August 1992). But we still don't know whether the seeds grew around cold dark matter, warm dark matter, cosmic strings, or something else.

If the universe is expanding, what is it expanding into?

To answer this question, we need to get into the geometry of four-dimensional spacetime. And the easiest way to do that is to return to the analogy of two-dimensional creatures living on an inflating balloon.

In this analogy, we can see that the balloon is expanding — but into a third dimension undetectable to the two-dimensional creatures on its surface. In our own case, we are three-dimensional creatures living in a four-dimensional spacetime. And like the balloon inhabitants, our universe is expanding into a higher dimension, the fourth. Unfortunately visualizing four dimensions is exceedingly difficult — I've never met anyone who could — so it's hard to get a good mental image of what we're expanding into.

Is there an edge to the universe, and if so, what lies beyond?

There is an edge to the universe, but it lies in time, not space. As we look farther out into space, we look further back in time. Look at the Moon on some clear night and you see it not as it is now, but as it was a bit over a second ago. Look at the Sun and you see it as it was eight minutes ago. Look at Sirius, the brightest star in the sky, and you see it as it was more than eight years ago.

You can carry this analogy as far as you want. You see nearby galaxies as they were a few million years ago; distant galaxies as they were billions of years ago. Eventually as you look out ever farther, you should be able to see to a time before the universe had formed any stars or galaxies.

When astronomers probing the universe with the Hubble Space Telescope or the 10-meter Keck telescope say they hope to see to the edge of the universe, they mean they want to observe back to a time when the first stars and galaxies were forming, probably some time between 1 billion and 2 billion years after the Big Bang. (The cosmic background radiation is, of course, even more distant, but astronomers usually don't mean that when they speak of the edge.)

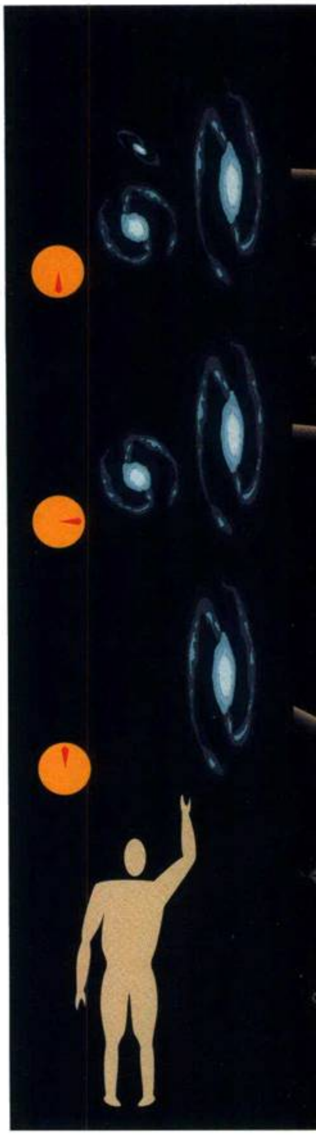
What lies beyond the edge of the most distant galaxies? Not much. Before stars turned on, the universe should have been profoundly dark. There's not much that astronomers could even hope to observe out there.

Did the universe expand faster than the speed of light during the inflationary period?

If you accept Alan Guth's inflationary hypothesis, then the answer is yes. The universe expanded by some one thousand billion billion billion times in about one-thousand billion billion billionths of a second, growing from roughly one centimeter in diameter to several hundred billion light-years across in a small fraction of a second. That's a speed far greater than the speed of light.

How can this be so? Many people know that Einstein's theory of special relativity implies that nothing can move faster than the speed of light. But fewer people realize that this is a restriction only on how fast matter and energy can move through space. Although special relativity restricts any object from traveling faster than the speed of light, it places no restrictions on how space itself can behave. Inflation demands that space expands, so the elementary particles that made up the early universe did not themselves move, but rather space carried them along.

What's the fate of the universe?

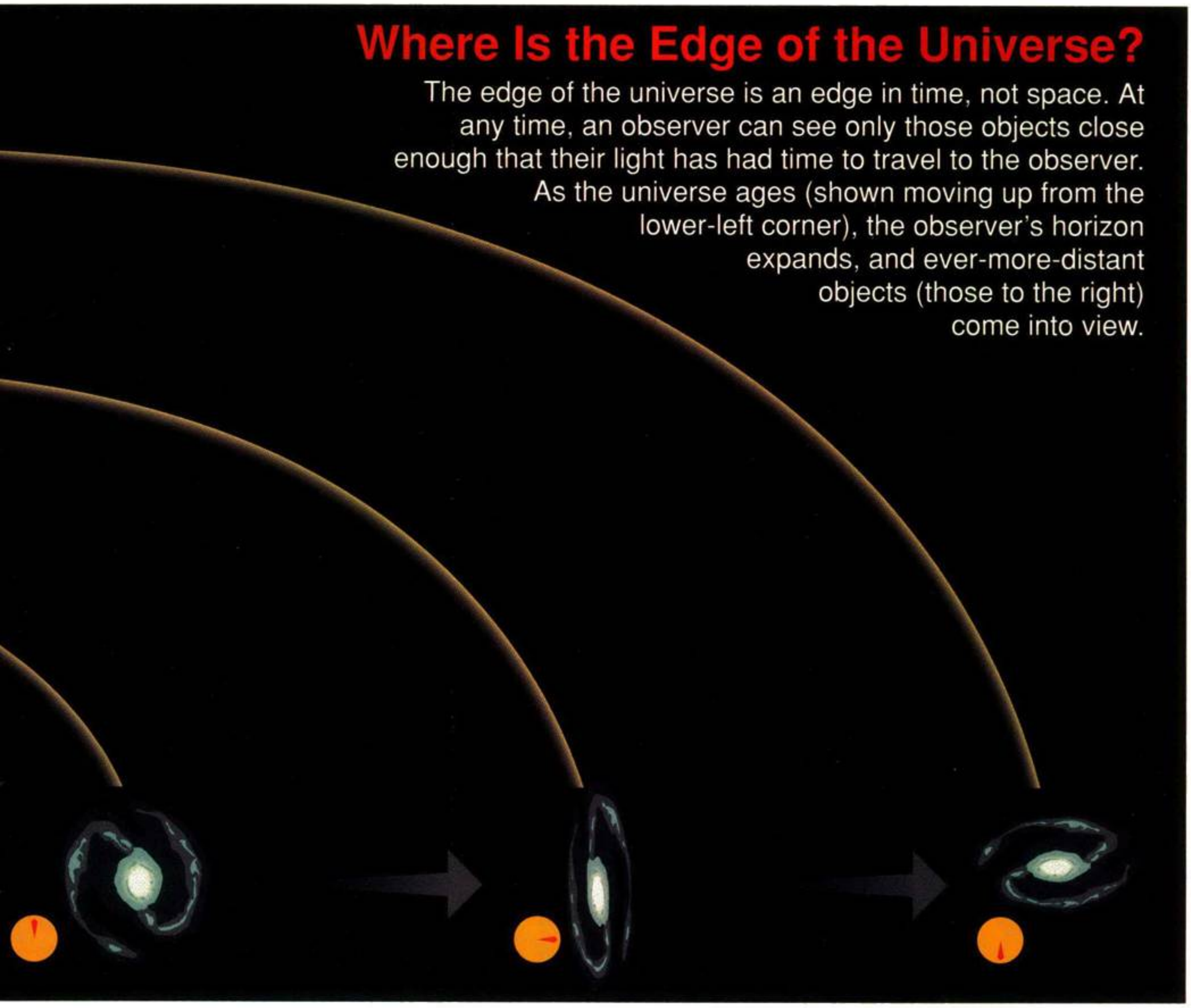


Does any question stir the imagination more than this? The surprising thing is that to a great extent we can answer it. Astronomers have a good idea of what will happen to the universe depending on how much matter it contains. The problem is that measurements of how much matter exists vary so much that none of the three possibilities can be ruled out entirely.

When astronomers look at the amount of matter visible in the universe — typically stars and galaxies — they tally only about one percent of the total needed to reach the critical density that will just barely stop the universe's expansion in the distant future. But when they look at the motions of stars in individual galaxies and of galaxies in clusters, they calculate that ten times more material must be exerting gravity than we can see.

The amount of this dark matter will determine the universe's fate. If there is not enough to boost the universe's density to the critical value, then the universe is considered "open" and will expand forever. There simply wouldn't be enough matter to exert the gravitational pull needed to stop the expansion. In this case, the universe will continue to expand and cool. Stars will go on forming for a long while, but the amount of material available for star formation will progressively dwindle. Eventually all the mass of the universe will be contained in dead planets and stars. The end of the universe will be the exact opposite of its beginning: a huge, utterly black corpse of a universe containing no light or heat.

If the universe has slightly more than the critical density of material, the universe is said to be "closed." The material will exert enough gravity to eventually halt the expansion and start a contraction. Ultimately all the matter in the universe would collapse back to a state of extraordinary temperature and density — the Big Crunch! — mimicking the conditions in the Big Bang that started the universe. What would happen after the Big Crunch? One possibility is that we live in an oscillating universe



Where Is the Edge of the Universe?

The edge of the universe is an edge in time, not space. At any time, an observer can see only those objects close enough that their light has had time to travel to the observer. As the universe ages (shown moving up from the lower-left corner), the observer's horizon expands, and ever-more-distant objects (those to the right) come into view.

where a Big Bang always follows a Big Crunch. Or perhaps the entire universe would disappear into a mammoth black hole, destroying space and time just as the Big Bang created it.

If the universe has just enough dark matter to reach the critical density, as Guth's inflationary theory demands, then the universe will also expand forever but at a rate that decreases essentially to zero. Although this universe falls in between the open and closed universes, the fate of the stars and galaxies will be much the same as in the open universe.

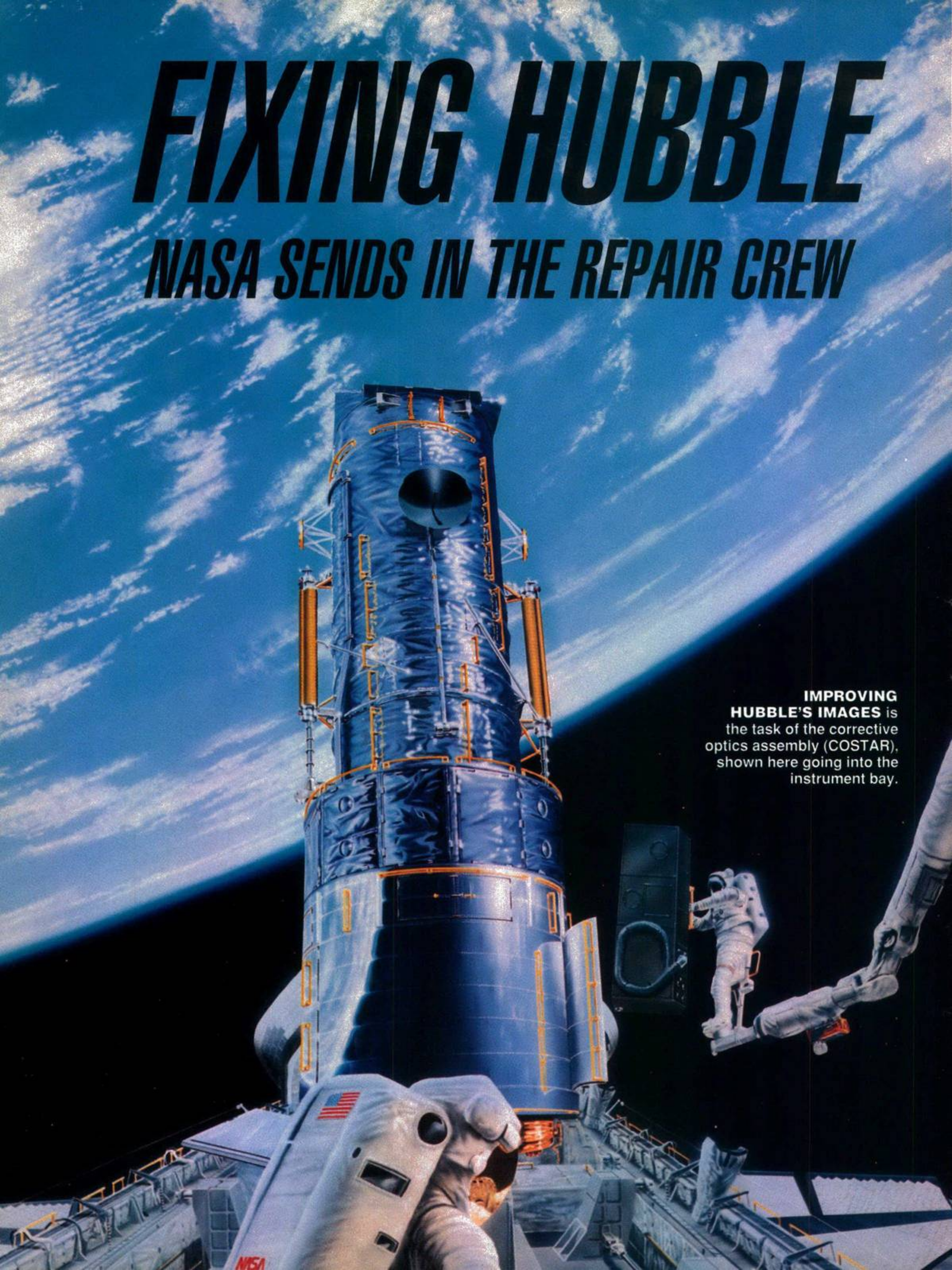
What ignited the Big Bang?

If we live in an oscillating universe, than a Big Crunch gave birth to the Big Bang. But in any case, learning what triggered the Big Bang is one area where cosmologists are still searching for answers. □

The Big Bang seems like such a simple idea: Everything in the universe, from the building blocks of matter to space and time themselves, burst forth at the same instant. Despite its simplicity, the theory describes the birth and evolution of the universe amazingly well. It only goes to prove that simple ideas are often the most powerful.

FIXING HUBBLE

NASA SENDS IN THE REPAIR CREW



IMPROVING HUBBLE'S IMAGES is the task of the corrective optics assembly (COSTAR), shown here going into the instrument bay.

December marks a milestone as astronauts repair the Hubble Space Telescope's blurry vision and troubled solar arrays and guidance systems.

by David Bruning

ASTRONAUTS PRACTICED every step of the Hubble repair mission, including replacing the solar arrays.

NASA

It's the moment of truth. After the loss of Mars Observer, delays in the launch of several shuttles, and antenna problems with Galileo, NASA has a lot riding on its mission to repair the Hubble Space Telescope. Clearly, astronomers eagerly await Hubble's fixed vision. But just as important, NASA's recent track record makes a successful mission imperative for continued public support of its programs.

To be fair, we should call the Hubble repair mission a servicing mission instead because engineers designed Hubble to have service calls throughout its life to replace instruments and worn-out parts. However, the first call came unexpectedly soon and with a higher than expected number of maladies. Astronauts will have their work cut out for them to get everything done during their five scheduled work sessions.

Setting Priorities

Although blurred vision is the most widely known ill of the space telescope, it isn't the most serious. Bigger problems lie with the solar arrays that power Hubble and the Rate Sensor Units (in NASA-ese called RSUs, they are essentially gyroscopes) that help point the telescope. The first gyro failed in December 1990, the second quit in June 1992, and a third developed problems in November 1992. The telescope has six gyros but needs only three to point. Because another failure would prevent astronomers from pointing the telescope, replacing these units is the highest priority.

The solar arrays expand and contract as the space telescope passes in and out of Earth's shadow during each 90-minute orbit. But the motion of the array causes the telescope to jitter and this, in turn, blurs the images. Ground controllers have developed new software for the array drives that alleviates much of the jitter, but occasionally the telescope loses its guiding lock on an object because of the flexure. So astronauts will replace these arrays and their drive system with new ones to prevent jitter.

After the team replaces the gyros and solar arrays, they will tackle Hubble's camera, the Wide Field/Planetary Camera (WF/PC) known as "wif pik." The astronauts will replace the camera with a new one, WF/PC II, that has special optics to compensate for the primary mirror's spherical aberration. (See "How We'll Fix Hubble," February 1993.) With the new camera, Hubble will improve its ability to see faint distant objects and have 10 times the typical resolution of the 10-meter Keck telescope, the world's largest scope.

The first servicing mission would have replaced WF/PC in any case. WF/PC II has newer charge-coupled devices (CCDs) than WF/PC so the new camera will have much lower noise. Also, the new CCDs require less cooling, which means fewer contaminants in space will collect on the camera's window and thus appear in images. WF/PC II will have the same wavelength coverage as the original camera (from 1,200 angstroms in the ultraviolet to 11,000 angstroms in the near infrared). But improved coatings will increase the sensitivity of the CCDs by up to a factor of two.

Lower priority fixes relate to the other scientific instruments. Astronomers will sacrifice the High Speed Photometer (HSP) to install the Corrective Optics Space Telescope Axial Replacement (COSTAR for short). This instrument provides a

Scott Kahler, Ball Aerospace and Communications Group

HOW THEY'LL FIX IT, STEP BY STEP

Extravehicular activity #1

0:00-0:45	Set up
0:45-3:00	Replace two gyro units
3:00-5:35	Prepare for repair of solar array Replace two electronic control units Replace fuse plugs
5:35-6:00	Clean up

Extravehicular activity #2

0:00-0:20	Set up
0:20-5:20	Replace two solar arrays
5:20-5:45	Clean up

Extravehicular activity #3

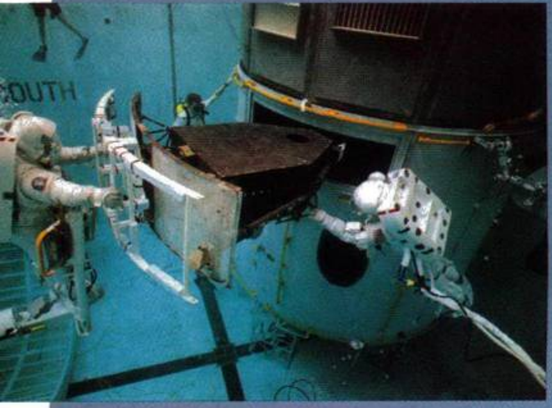
0:00-0:20	Set up
0:20-4:35	Remove Wide Field/ Planetary Camera Install Wide Field/ Planetary Camera II
3:00-5:35	Install new magnetometer
5:35-6:00	Clean up

Extravehicular activity #4

0:00-0:20	Set up
0:20-3:30	Remove High Speed Photometer Install COSTAR
3:30-5:00	Replace drive electronics for solar arrays
5:00-5:25	Clean up

Extravehicular activity #5

0:00-0:20	Set up
0:20-1:15	Install Goddard High Resolution Spectrograph redundancy kit
1:15-2:55	Install DF-224 computer coprocessor
2:55-3:55	Clean up



NASA

THE WIDE FIELD/PLANETARY CAMERA II slides into its bay.

series of mirrors that will fix Hubble's vision for the other three instruments — the Faint Object Camera, the Faint Object Spectrograph, and the Goddard High Resolution Spectrograph.

After COSTAR is in place, astronauts will, if the repairs remain on schedule, turn their attention to other problems. A faulty power supply has the Goddard High Resolution Spectrograph stuck on the longer (1,150 to 3,200 angstroms) of its two wavelength sides. A patch (NASA calls it a redundancy kit) between the power supplies on both sides would enable them to use the short wavelength side (1,050 to 1,700 angstroms) as well.

Hubble's on-board computer (called the DF-224) has started having memory problems. This situation is not yet critical because only one of six memory units has failed, a second unit has only partially failed, and the computer needs only three units to function. If time remains while the astronauts are on their service call, they will install a second computer processor that will increase memory and the speed of some operations.

Making It Happen

Cramming these repairs into an 11-day mission is the task of the crew of Endeavour (shuttle flight number STS-61). Piloting the orbiter is Ken Bowersox, Richard Covey is mission commander, and Story Musgrave the payload commander. Mission Specialists are Tom Akers, Jeff Hoffman, Kathy Thornton, and Claude Nicollier (a European Space Agency astronaut). Greg Harbaugh is the back-up mission specialist. These astronauts have collectively flown on 13 space missions.

Their training almost makes marathon runners look like couch potatoes. Akers and Thornton have mission experience from STS-49 flown in May 1992 to rescue the Intelsat communications satellite and to test Space Station assembly methods. Akers was one of the astronauts who grabbed the satellite so they could put a new rocket motor on it.

Over 100 training sessions honed their skills. The training included 394 hours in water tanks, simulating the weightlessness of space to rehearse sliding in the wedge-shaped WF/PC II and handling the telephone-booth-sized COSTAR. Simulations of the actual repair procedures totaled more than 190 hours, including one test mimicking the final two days of Hubble repairs that alone lasted 59 hours. The most high-tech practices used virtual reality — computers hooked up to motion-sensing gloves and video-display helmets. These devices simulated the cargo bay of the shuttle and allowed the astronaut controlling the arm to practice coordinating his movements with those of the astronaut riding on the arm during the repairs.

The repairs will take place on five days during shifts of up to six hours. Mission specialists, who will have more than 80 tools at their disposal, will work in pairs and suit up on alternate days. Two shuttle missions have tested certain tools to ensure that they work in space and debris generated by the tools doesn't contaminate the telescope.

All in a Day's Work

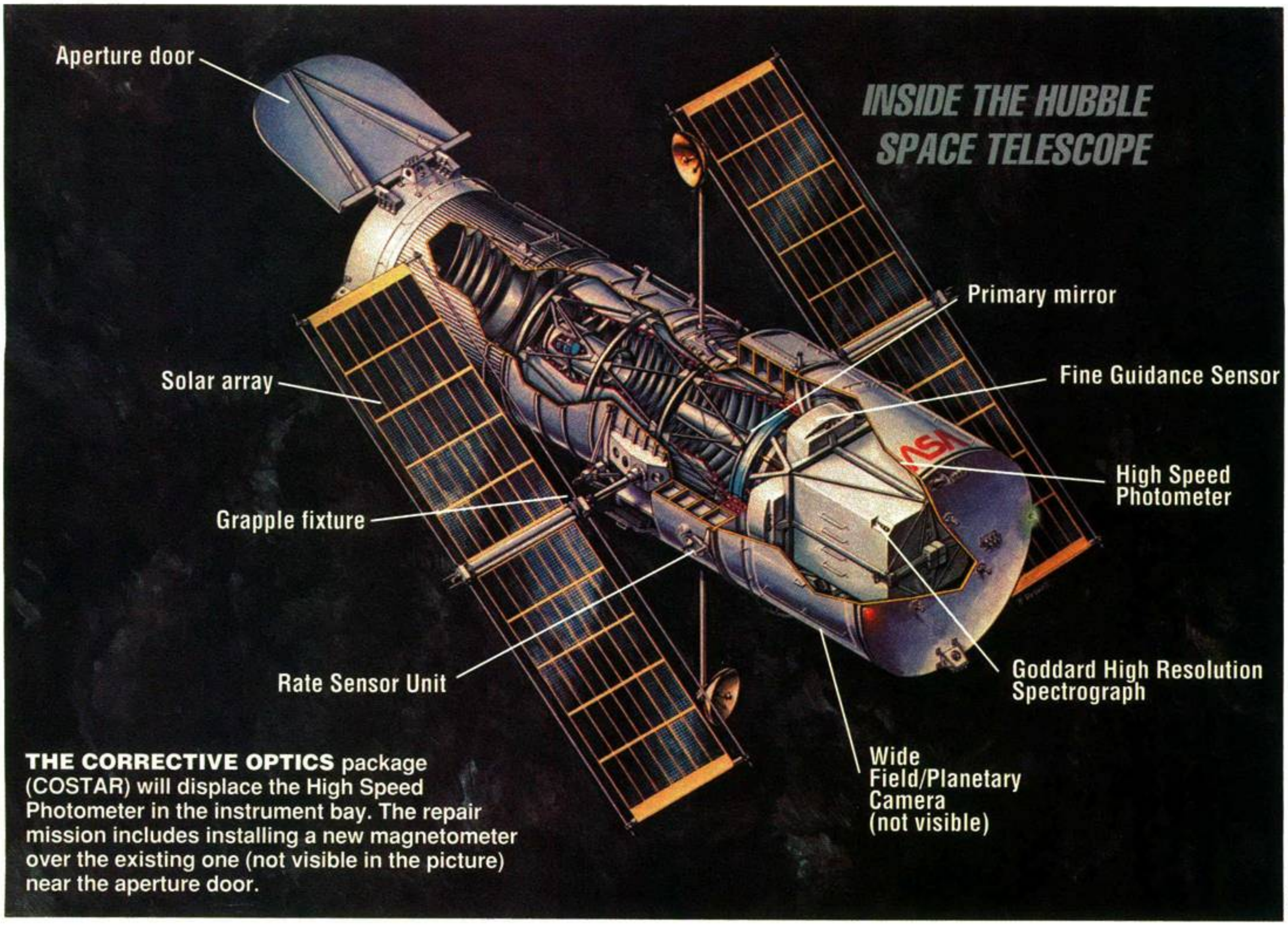
Mission planners have produced in-depth schedules for each of the 11 days in space. The schedule I report here is a preliminary one: Further fine adjusting of repair priorities may change this schedule, and of course unforeseen problems in flight may also affect it.

Day one starts with the launch of the shuttle. The astronauts will spend the rest of day one and all of day two checking out the space suits and robotic arm and maneuvering the orbiter to link up with Hubble. Telescope controllers will have already placed Hubble in a safe mode, with the aperture door closed to prevent the shuttle's engines from contaminating the mirror.

On day three, the astronauts will grab Hubble with the robotic arm and place the telescope in the servicing fixture located in the orbiter's payload bay. This will hold the scope securely and free up the robotic arm for use during the repairs. The astronauts will then transfer Hubble's power from its solar arrays to the shuttle.

Hubble repairs occur on days four through eight. The timeline at left lists the activities. Each extravehicular activity, or EVA, starts with setting up equipment and ends with cleaning up. EVA #1 fixes the gyros and related electronics and their fuses. EVA #2 concentrates on the solar arrays. The third EVA replaces WF/PC with WF/PC II and also installs a new magnetometer, which Hubble uses as part of its pointing control system. EVA #4 installs COSTAR and new drive electronics for the solar arrays. The last EVA is also the shortest and takes care of the DF-224 computer and Goddard High Resolution Spectrograph repairs.

Mission planners are holding two days in reserve for additional EVAs, if needed. But if all is successful, the


INSIDE THE HUBBLE SPACE TELESCOPE
Aperture door
Primary mirror
Fine Guidance Sensor
Solar array
High Speed Photometer
Grapple fixture
Rate Sensor Unit
Goddard High Resolution Spectrograph
Wide Field/Planetary Camera (not visible)

THE CORRECTIVE OPTICS package (COSTAR) will displace the High Speed Photometer in the instrument bay. The repair mission includes installing a new magnetometer over the existing one (not visible in the picture) near the aperture door.

NASA

last EVA will occur on the eighth day of the mission. On day nine, astronauts will release Hubble and slowly move away from it and then rest on day 10. They'll check out the re-entry systems on day 11, preparing for their return home on day 12.

Focus Please

After the astronauts move far enough away from the space telescope and the engine gases have dissipated, telescope controllers will open Hubble's aperture door. But don't expect the telescope to have perfect vision and produce lots of sharp images right away. Astronomers will spend 13 to 15 weeks aligning and fine-tuning the telescope's optics.

During the first two weeks, instrument scientists will take a number of "baseline" images to see if the servicing mission bumped or moved anything inside. These exposures will also enable them to evaluate image improvement during the focus and alignment procedures in the weeks ahead. They will take another five weeks to carefully focus WF/PC II.

The long period is necessary because focusing Hubble isn't as easy as focusing your backyard telescope. WF/PC II has a number of mirrors that must be moved to focus and align the instrument. And the alignment itself can introduce other aberrations into the image if not done carefully.

When finished, WF/PC II should put 60 to 70 percent of a star's light into a disk just 0.2" across. This is five times better than WF/PC presently provides with its uncorrected optics. NASA expects to release the first images from WF/PC II about eight weeks after the servicing mission.

As they work on focusing WF/PC II, astronomers will also turn their efforts to COSTAR. They'll swing in the corrective mirrors for the Faint Object Camera first and expect to finish its alignment and focusing around the tenth week. The alignment and focusing of the Goddard High Resolution Spectrograph and the Faint Object Spectrograph will follow three to five weeks later.

Hubble's Future

By the eighth week and the expected release of the WF/PC II images, everyone will know whether the servicing mission was a complete success. If so, plans will proceed for future servicing missions. The next mission will see the installation of the Space Telescope Imaging Spectrograph and the Near Infrared Camera Multi-Object Spectrometer. NASA has tentatively scheduled this second mission for 1997.

A third servicing mission may take place in 1999. This mission would replace WF/PC II with an Advanced Camera but other details of this service call aren't yet available.

The present service call has already cost over $250 million, but most of this cost went toward planned servicing. The $86.3 million to fix Hubble's vision came from slowing the development of some next-generation instruments such as the Imaging Spectrograph or scaling down others such as WF/PC II.

Will the costs be worth it? We won't know until January or February 1994. But NASA is giving this house call everything it's got, including one of the most highly trained crews ever sent into space. The space agency knows that more than the Hubble Space Telescope is at stake. Its future — and the shape of America's future in space — rides on how well NASA gets this job done. ☐

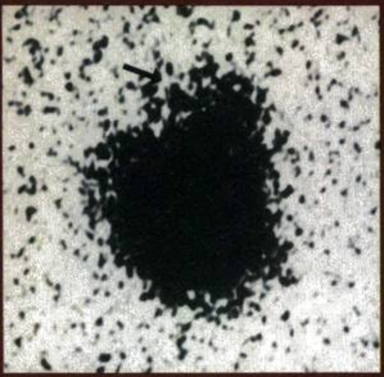
At the edge of night
Pluto & Charon

Pat Rawlings/NASA-SAIC

Two worlds on the rim of the solar system hint at what lies beyond the realm of the planets.

The next step is a spacecraft mission — and it's already on the drawing board.

by Robert Burnham



U.S. Naval Observatory

AN ACCIDENTAL DISCOVERY in 1978, Pluto's moon Charon (arrow) could have been found decades earlier. It gave astronomers a means of weighing Pluto.

A moderate wind is blowing, fiercely cold and thinner by far than the highest jet stream on Earth. The breeze scuffles across a pinkish frosted landscape only slightly warmer than the coldest temperature in the universe. The Sun, a tiny arc light, casts razor-sharp shadows in the eerie gloom.

A giant moon hangs in the sky, more than seven times the apparent size of Earth's Moon. Its soft white light bathes the landscape, filling shadows with a faint glow.

It's noontime on Pluto.

During the last decade, Pluto and its moon Charon have come in from the cold, scientifically speaking. Once a featureless enigma, Pluto is now a world whose surface has been crudely mapped. Scientists know something of its surface and even its interior; they also know that its surface differs markedly from the surface of its moon. And as they study this fascinating little world with the giant moon, they have begun to see the pair as a stepping stone to that part of the Sun's family that lies beyond the planets.

It's kind of funny, then, that it all began with a mistake. In fact, Pluto's discovery was the result of wrong assumptions, erroneous measurements, and off-track guesswork.

The Late Great Planet X

Around 1900, if celestial mechanicians felt cocky, they had reason. Just half a century earlier, by measuring irregularities in the motion of Uranus, they had predicted exactly where astronomers would discover a new planet. Soon found, it was called Neptune. And when it appeared that Neptune's gravity couldn't explain all of Uranus' movements, many astronomers jumped to the conclusion that some unknown "Planet X" must lie beyond Neptune.

Percival Lowell was among them. Today when you think of Lowell, Martian canals come to mind. But at the turn of the century, Lowell was respected far more among astronomers for his mathematical talents than for his views about dying civilizations on Mars. Lowell attacked the Planet X problem several times and set the observatory he founded in Flagstaff, Arizona, on course to find it. And find it Clyde Tombaugh eventually did — in 1930, at Lowell Observatory — but only after a long search and years after Percival Lowell's death.

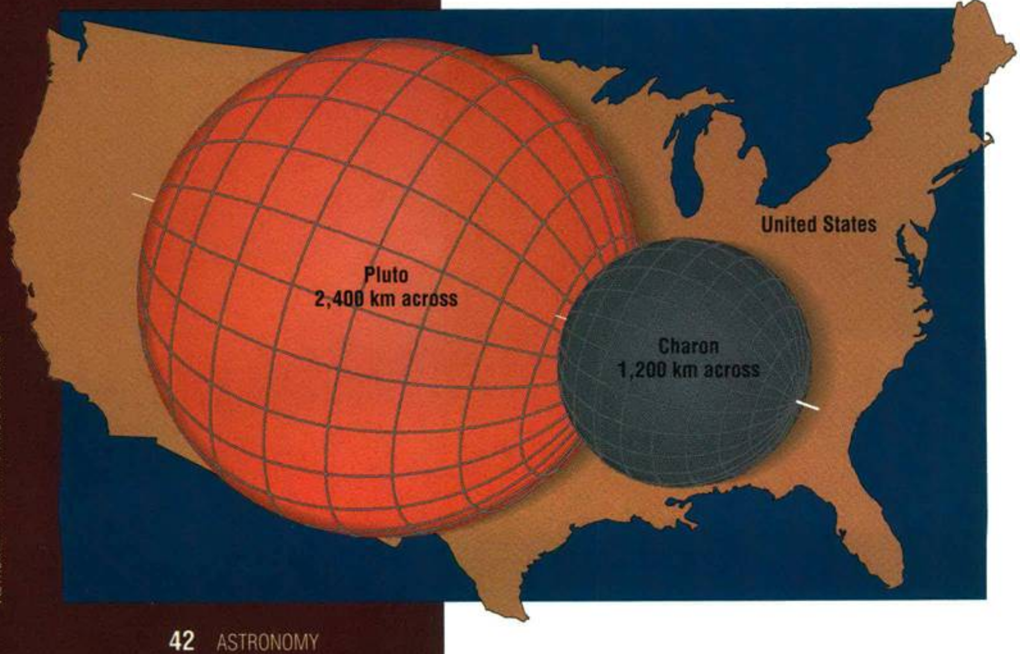
The problem was that the real Pluto turned out to be much too small to account for its supposed tugs on Neptune and Uranus — unless it was made of something ridiculously improbable, like pure lead. Years passed, and astronomers made ever more refined measurements of Pluto's putative gravitational effects. With each new measurement, Pluto's estimated mass dropped. Finally it became an in-joke: Two astronomers predicted that if its mass continued to decrease as it had in study after study, Pluto would vanish from the universe sometime in 1984.

Double Planet

In 1978, before Pluto could disappear, James Christy (of the U. S. Naval Observatory) discovered that it has a moon. Examining Pluto's image on many photographic plates, Christy noticed that it often appeared lopsided, while star images on the same plate were round dots (see at left). Moreover, Pluto's lopsidedness came and went every 6.39 days, the same period in which Pluto was believed to rotate, based on its small but regular changes in brightness. He guessed that the bulge on Pluto was the unresolved image of a moon — and he was right.

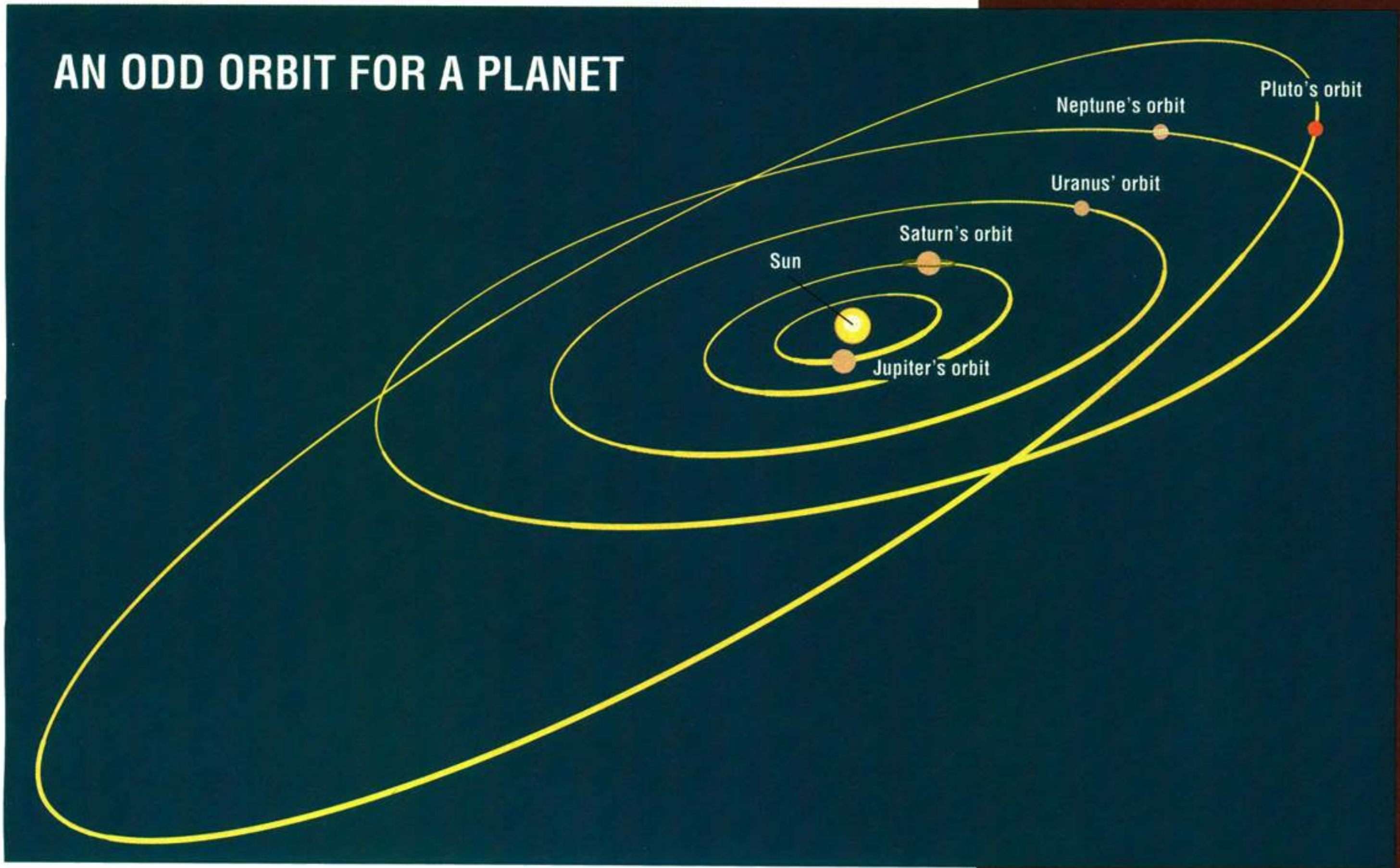
This new moon was named Charon, after the mythological centaur who ferried the souls of the dead across the River Styx to the underworld ruled by the god Pluto. (How do you pronounce it? Following mythology, many astronomers say KAH-ron, others use SHAH-ron; take your pick.) Charon orbits at a distance of 19,600 kilometers from Pluto's center. This is so close that over eons, tidal forces have "relaxed" the pair's rotation so they keep one face turned toward each other all the time.

A REAL DOUBLE PLANET, Pluto and Charon form a pair closer in size and mass than any other planet and moon.



ASTRONOMY: Phil Kirchmeier after JPL

AN ODD ORBIT FOR A PLANET



PLUTO'S TILTED ORBIT brings it inside the orbit of Neptune, but orbital resonances keep the two planets far apart.

Jim Christy almost wasn't the first to find Charon. Early in 1950, Gerard Kuiper and Milton Humason each hunted for moons of Pluto with large telescopes. But they figured that any moon had to be both extremely faint and relatively far from Pluto, so they exposed their plates for a long time. This was fatal because it hid the closely orbiting Charon in the overexposed image of Pluto. If Kuiper or Humason had used shorter "snapshots," either might have found Charon almost 30 years before Christy did.

Luck has continued to exert an effect in Plutonian affairs. When astronomers plotted the new-found moon's apparent orbit they got a surprise. Starting in 1985 — *just* seven years after its discovery — a series of mutual eclipses, occultations, and transits would begin, with Charon alternately passing in front of and behind Pluto (see page 45). Had Charon not been discovered when it was or soon after, astronomers would have had to wait half a Pluto year — 125 Earth-years — for the next series to occur.

The mutual events were a godsend: Charon, in effect, became an optical knife-edge dissecting the globe of Pluto. Astronomers knew the two would appear as an unresolved dot of light. But they calculated that precise brightness measurements, coupled with a knowledge of the objects' relative positions, would enable them to map the broad light and dark features on parts of both planet and moon.

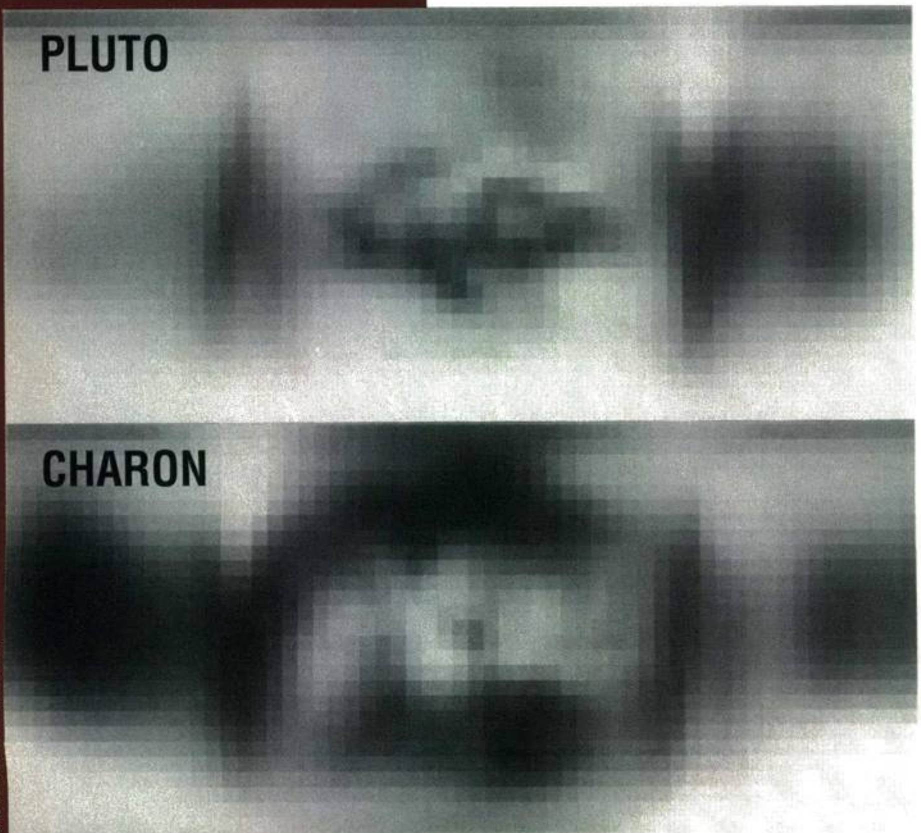
By the time the mutual events finished in 1990, astronomers had huge databanks of observations. Using various mathematical routines, several teams of scientists inverted the data, turning Pluto's minute brightness changes into maps of its surface (see page 44). The techniques produced results that display remarkable agreement. At the same time, astronomers found that Pluto's surface is generally reddish, while Charon's is gray.

The mutual events also showed Charon is large: 1,200 km in diameter — fully half Pluto's 2,400-km diameter — and its mass is about 1/11th of Pluto's, also unusually high. Uncertainties hover around how much each object weighs in real terms, but it's clear that the total of both comes to no more than 1/400th the mass of Earth, or about 1/5th that of our Moon alone. While Earth and Moon are sometimes called a double planet, the Pluto-Charon system has a far better claim on the title. No other planet and moon come so close to each other in relative size or mass.

But if Pluto is so small, what about the long-sought Planet X perturbing Uranus and Neptune? The late astronomer Robert Harrington long championed the idea that since Pluto was too puny to account for discrepancies in the motion of

Space Telescope Science Institute

HST SPLITS A DOUBLE PLANET, but mapping the surface of Pluto called for a lucky quirk of geometry (opposite) and lots of computer power.



Marc Buie/Lowell Observatory

MAPS OF PLUTO AND CHARON emerged from computer analyses of their mutual eclipses and occultations.

Uranus and Neptune, the *real* Planet X was yet to be found. He calculated possible locations for it, but no object ever turned up. Then a paper published last summer by JPL astronomer Myles Standish put Planet X to rest, likely for good.

Standish took the masses of Jupiter, Saturn, Uranus, and Neptune (as directly measured by the flights of the Voyager spacecraft) and showed that if you plug the planets' updated masses into the equations, the anomalies of motion disappear. The supposed irregularities came from errors in measurements, not from any planets lying beyond Pluto. Planet X is dead. But if it proved in the end to be a fiction, it nonetheless served a useful purpose by spurring the discovery of the very real Pluto.

Worlds of Rock and Ice

The face of Pluto seen in the mutual-event maps is murky and indistinct. What's the place like *really*? No one will know for sure until we send a spacecraft. But many planetary astronomers might say that if you want a sneak-preview of Pluto, take a look at Neptune's moon Triton. However it's not quite that simple.

Voyager 2 flew past Triton in 1989. It found a world 2,700 km in diameter (vs. Pluto's 2,400) with a density of 2.1 grams per cm^3, virtually matching Pluto's. Both have white polar caps of nitrogen ice and surface temperatures of about 37 kelvins (−393° F). Even their atmospheres are similar: thin, dominated by nitrogen, with carbon monoxide present. (Triton also has methane, while the jury's still out regarding Pluto.)

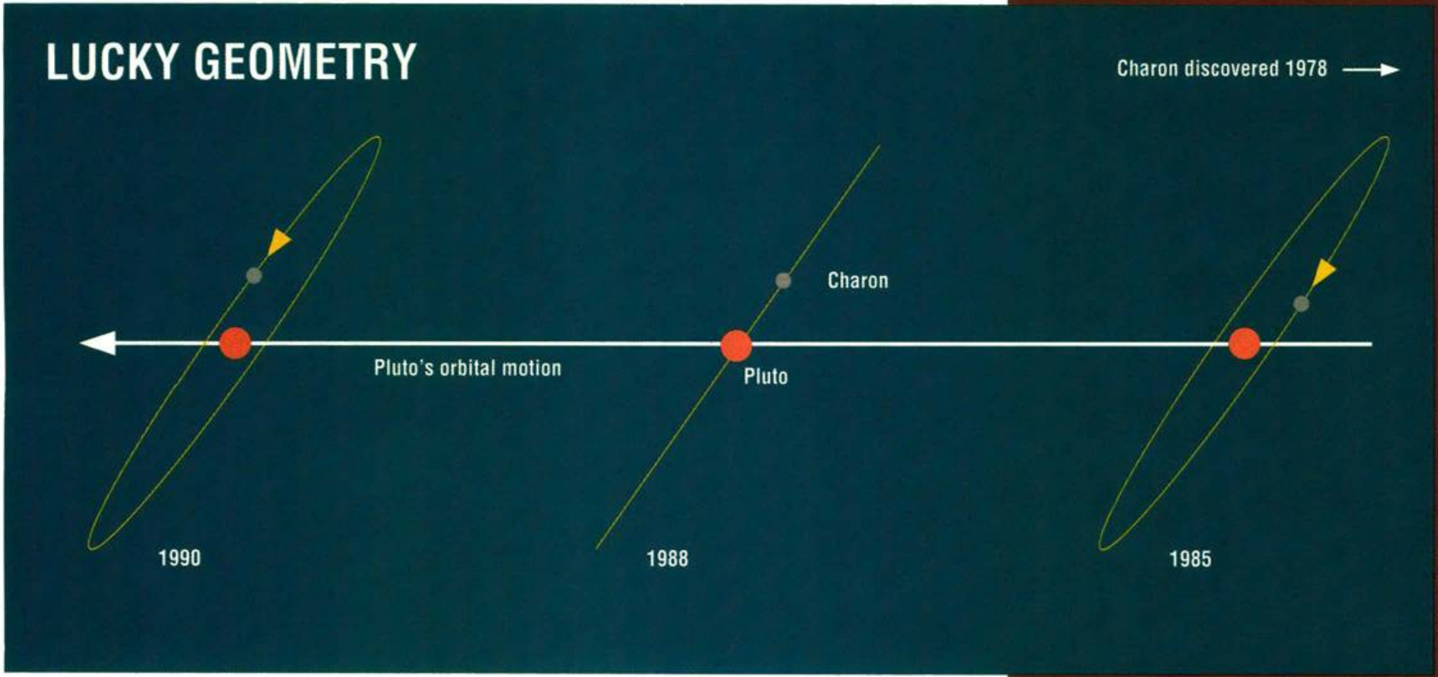
Triton's surface ices have a pinkish tinge, as do Pluto's. Scientists think this comes from the Sun's ultraviolet light reddening methane frost on their surfaces. (Charon, however, has a gray surface of water ice. It's also darker than Pluto, reflecting some 38 percent of the light, while Pluto reflects an average of 55 percent.)

But despite similarities to Triton, Pluto *has* to be different. Triton was captured long ago by Neptune and the tidal heating of that wrenching event was enough to power geological activity, including geysers spouting off even today. Pluto, scientists think, never underwent such tidal turmoil. Its surface probably looks somewhat like Triton's but with less volcanic activity and more cratering. Pluto's orbit carries it out into the Kuiper disk, a realm on the edge of the planetary system populated with long-period comets and planetesimals like 1992 QB$_1$, 1993 FW, 1993 RO and 1993 RP (see "A New Member of the Family," December 1992, and AstroNews, December 1993). Impacts at Pluto will occur 100 times more frequently than at Earth.

Polar caps pose a mystery on Pluto and Triton. Given the severity of polar night on both worlds, atmospheric gas would migrate from the sunlit warmer regions toward the pole in darkness, where it would freeze out as a bright layer of ground frost. But on Triton — and if the mutual-event maps are accurate, on Pluto as well — the bright pole isn't the one that has most recently been in darkness. Instead, it's the pole that has been in sunlight for decades. Why? There's no good explanation.

Astronomers didn't know that Pluto even had an atmosphere until 1988, when the planet happened to pass in front of a star. If Pluto were airless, the starlight would have snapped off instantly. Instead, it faded over several seconds, the unmistakable signature of an atmosphere. Further study revealed how thin it is. At the surface the pressure is just 3 microbars, or about the same as Earth's atmosphere 80 km high. The whole thing would make a ball of ice just 1 km in diameter. Except near the surface, the atmospheric temperature is 105 kelvins (–270° F). At the surface, the temperature is only 37 K (–393° F) because the ground, being highly reflective, has cooled. Winds blow about 20 meters per second (45 mph).

The atmosphere has to be nearly transparent or the mutual events wouldn't



Robert Marcialis/Pima Community College

show surface features. But the way starlight disappears behind Pluto strongly hints at haze or some refractive peculiarity in its lower layers. The question is more than academic because stellar occultations offer the best way of determining Pluto's size. Thus scientists are stuck with two diameter figures, one around 2,400 km from the stellar occultations and the other about 100 km smaller based on the mutual events. Unfortunately, the uncertainty implies different densities, which prevents scientists from making a good model for Pluto's internal structure. In essence, though, Pluto is 60 or 70 percent rock by volume with the remainder mostly water ice.

But what are Pluto and Charon? Where did they come from? It's clear they aren't Jupiter, Saturn, Uranus, or Neptune, nor do they much resemble Mercury, Venus, Earth, or Mars. Despite their differences, Pluto's closest living relative is probably Triton. Some scientists have come to think Pluto and Triton are a couple of icy planetesimals that escaped being swept up by the outer gas giant planets. Triton almost was, but was captured into orbit by Neptune. (See "Where Has Pluto's Family Gone?" September 1992.) Such objects are rare now, although they were once ubiquitous, being the building blocks of planets.

A Mission to Twilight?

The problem with studying the nature of Pluto and Charon is that Earth-based research will reach a limit at some point. To learn significantly more a spacecraft is needed. Some 4.5 billion km from Earth — that's about 4 light-hours — Pluto is the last unvisited planet in the solar system. Experience from other missions shows that close-up views, even if snatched during a hurried flyby, add immeasurably to what's known. So important is a spacecraft visit that it's virtually like discovering the planet afresh.

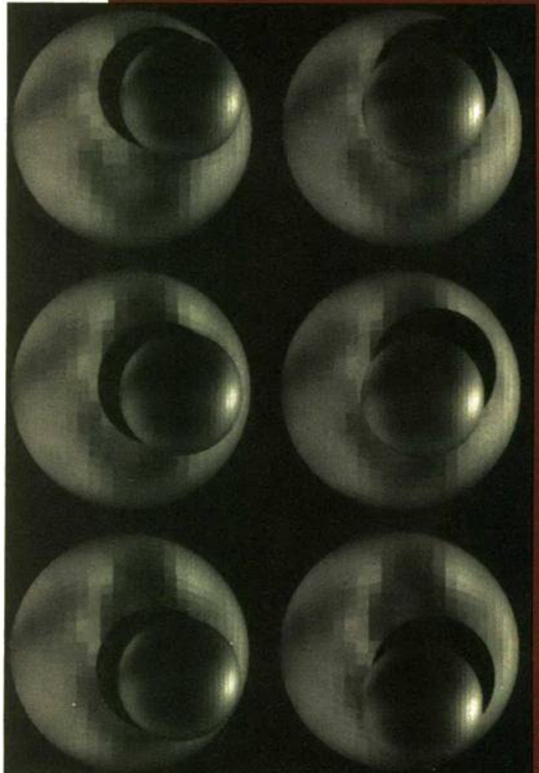
The Jet Propulsion Laboratory in Pasadena, California, has proposed a mission called the Pluto Fast Flyby, or PFF for short. It's fast because plans call for the spacecraft to encounter Pluto 6 to 8 years after launch, and it's a flyby because that's the cheapest mission worth doing. For insurance and to increase the amount of science, JPL envisions building a pair of spacecraft.

Two reasons urge speed. First, Pluto is now gliding away from the Sun in its orbit and cooling off. As it chills out, the atmosphere will freeze onto the surface as frost. Scientists don't know how long the process will take, but they expect the entire atmosphere will have turned to frost by 2010 to 2020.

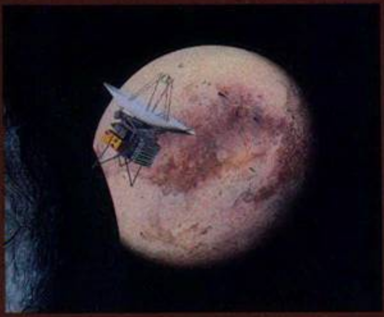
"Pluto behaves like a comet on a planetary scale," notes planetary scientist Alan Stern. Each Pluto year, the atmosphere boils off the surface as the planet approaches the Sun at perihelion, only to freeze out again as Pluto moves away toward aphelion. Its atmosphere won't reappear until Pluto nears its next perihelion — in 2237.

The second reason for sending a mission soon lies in Pluto's seasons. With axes tipped

SLICING ACROSS PLUTO'S DISK like an optical knife-edge, Charon made repeated passes in front of Pluto and behind it between 1985 and 1990. These mutual events (simulated below) let astronomers map Pluto's surface (opposite).



Marc Buie/Lowell Observatory



Pat Rawlings/NASA-SAIC

A DOZEN YEARS HENCE, the Pluto Fast Flyby spacecraft will give us a look at the ninth planet and its moon.

122° to Pluto's orbit, the poles of Pluto and Charon undergo decades-long, sunlit summers alternating with winters of utter darkness lit only by starlight. Right now, the Sun lies near Pluto's equator, but its south polar region is slipping away into night. No one alive today will be around when the Sun again rises over these regions. By 2005 less than 10 percent of Pluto and Charon will be in darkness, but by 2015 the areas lost from view will increase to 20 percent. By the 2030s, shadow will hide nearly half the planet and its moon in impenetrable darkness.

JPL hopes the Pluto mission will get new-start funding in 1994 or 1995, with a 1998 launch. JPL's first plans envisioned a spacecraft weighing 150 kilograms, which would yield a flight time of 8 years. But mission scientists and engineers think they can pare the spacecraft down to 110 kg, shortening the flight to just 6 years. Flybys would thus occur in 2004 or 2006, within the atmosphere's probable remaining lifetime and while about 90 percent of Pluto and Charon are still visible.

Insurance aside, paired craft offer better science. The probes will be traveling 15 to 20 km per second at encounter, too fast to image both halves of Pluto and Charon at the desired 1 km resolution. So mission planners will time the arrival of the second craft to photograph the opposite side of Pluto and Charon from the first flyby. Planners also intend to allow roughly a year to elapse between the encounters. This will let the scientific results of the first flyby influence the detailed plans for the second. It will also give Pluto (especially its atmosphere) the chance to change a little, providing a better long-term picture.

Very Tight: Focus & Budget

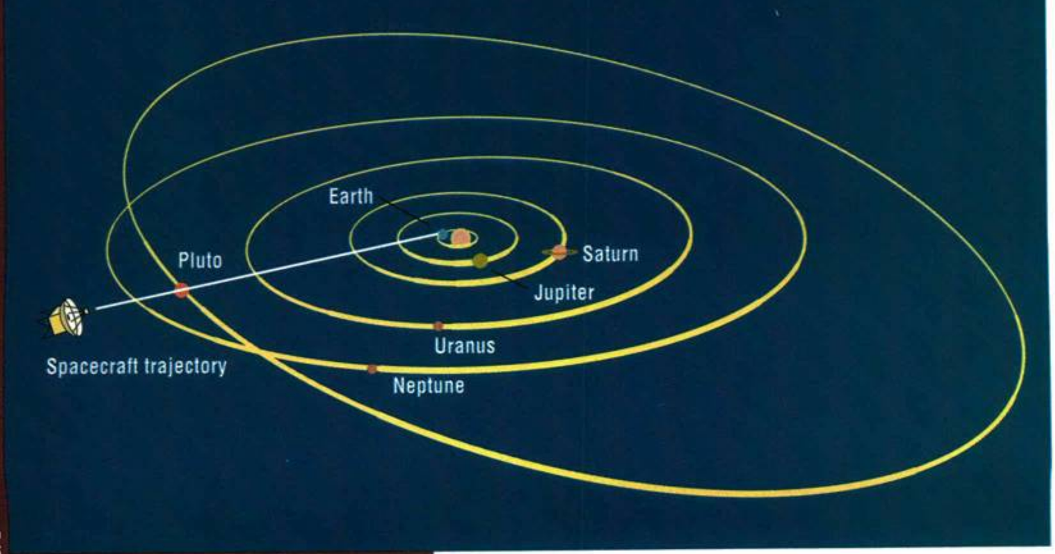
In keeping with NASA's new theme of faster, cheaper, better (see "Cheap Shots," August 1993), project planners have trimmed the Pluto mission's science objectives to a bare minimum. The basic "must-do" list contains mapping the geology and landforms of Pluto and Charon, studying their surface compositions, and probing Pluto's atmosphere.

Additional goals rated as "important" include detecting changes in both objects, imaging the ground in stereo to measure topography, searching for a possible atmosphere around Charon, and mapping the two bodies' surface temperatures. Lastly, scientists rank as "desirable" seeing how the Sun's charged particles behave near Pluto and Charon, detecting a magnetic field (if any), and looking for additional satellites or possibly a ring.

The wish-list looks formidable *in toto*, but scientists think they can achieve nearly all the objectives with just three on-board instruments plus an experiment using the radio transmission link from Earth. The three instruments are all imagers of some kind: a visible-light CCD camera and two spectrometers, one working at infrared wavelengths, the other in the ultraviolet. The visual camera will be the workhorse for geology studies and mapping, while the two spectrometers will focus on surface composition. Scientists expect to identify minerals and ices by comparing the reflectivity of Pluto at different infrared and ultraviolet wavelengths.

The radio experiment will probe Pluto's atmosphere. Scientists hope to detect winds, map the temperature at different altitudes, and look for composition differences from place to place and by altitude. The technique is the same as that used on previous spacecraft: As the craft speeds behind the planet its radio signal slices down into the atmosphere. This changes the signal in ways which, when analyzed on the ground, can tell scientists a lot about the atmosphere and its structure. But Pluto is too far away for the craft to send Earth a signal strong enough to be analyzed as previous missions have. So on this mission the spacecraft must do the sci-

LIGHT THE FIRE AND GO

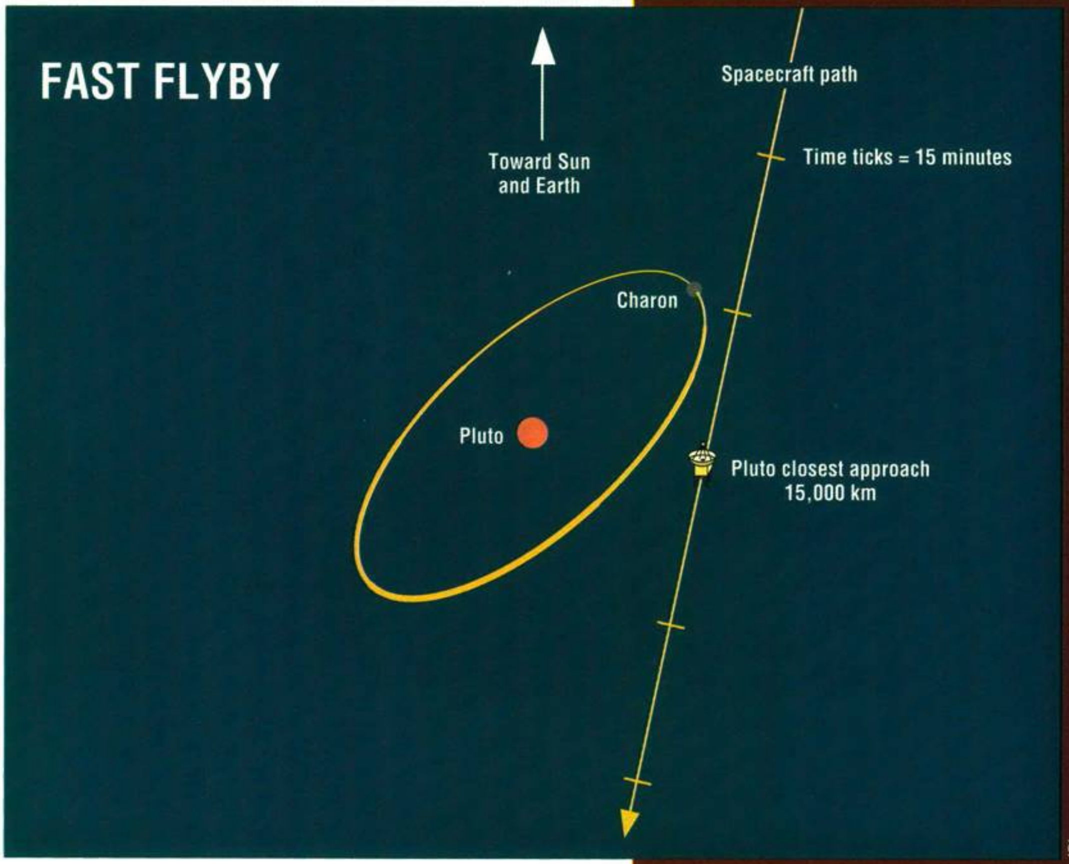


A STRAIGHT SHOT TO PLUTO should get the Fast Flyby spacecraft out to the planet before its atmosphere disappears sometime around 2015.

JPL

ence onboard using a powerful radio signal beamed from Earth.

Because Pluto lies too far away for direct control, each craft will fly the entire encounter by itself, recording all data in its 400-megabyte solid-state memory. After encounter, the craft will spend the first month radioing back the most urgent science data and 11 more months trickling down lower priority results. Although its mission will nominally end one year after flyby, the craft will continue its headlong flight out of the solar system toward 18h right ascension, –16° declination. Traveling at 3 to 4 astronomical units per year, scientists think it may reach the boundary of the solar wind some 30 to 40 years after the flyby.



JPL

Countdown to Encounter

The encounter actually starts about four to six months before the flyby. That's when the spacecraft begins scientific imaging as its camera finally sees Pluto better than the Space Telescope can from Earth. Two pixels across, then four, then eight: slowly the planet and moon grow on the craft's silicon retina. Five days before encounter, with the spacecraft approaching at just over 18 km per second, Pluto measures about 30 pixels across.

The last days count down quickly. The spacecraft snaps picture after picture as it scans the growing pair of worlds. It looks for faint satellites, hydrogen coronas, and airglows. Scientists collect on bets with colleagues as features discerned only dimly from Earth swim into clarity. One day before closest approach, Pluto will be more than 90 pixels across. As the last hours unfold, the planet and its moon grow until it takes mosaics of frames to cover them.

Fifteen minutes before the Pluto encounter, the craft races past Charon. Then, after years of flight, closest approach to Pluto comes and goes in an instant, with the high-resolution camera reaching out to snap features only 150 meters across.

The craft could pass closer than the actual 15,000 km, but surface details would be smeared by the speed of the flyby. As it is, the craft has to roll during exposures to keep target areas unblurred.

Next comes occultation, when radio signals from Earth probe the structure of Pluto's atmosphere. The cameras will also look back at Pluto and Charon, hoping to detect dust rings, clouds, and other features seen best when backlit.

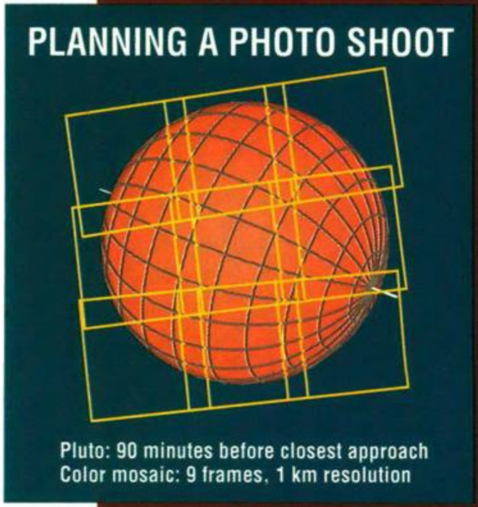
Then, abruptly, it's over.

Planet and moon recede swiftly astern. The craft starts to send back the pictures and data to a waiting Earth eager to get its first views of this most distant world.

Months pass and the spacecraft continues to drain its memory banks. One day, the last electronic bit is sent and acknowledged. For this craft, the Pluto mission is over. Its companion, traveling 14 months behind but already closing in on Pluto, will have its encounter fine-tuned in light of the results sent back.

The craft now faces an eternal flight into the interstellar night. Its final duty to Earth will be to listen to the faint whisper of electrons surging in the shifting magnetic fields of space.

Then one day, when the craft is deep in the icy gloom on the edge of the Sun's domain, it will cross out into galactic space. If it still functions on that long-distant day, it may add a mite of knowledge — and help us link the study of our home planets to that of the stars and our Galaxy. ☐



Pluto: 90 minutes before closest approach
Color mosaic: 9 frames, 1 km resolution

JPL

FRANTIC ACTIVITY AT PLUTO will climax the spacecraft's 6 to 8-year flight from Earth.

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Built to last a lifetime. Primary and secondary mirrors are aluminized and SiO overcoated for durability. Cabinet-quality laminate finish resists dirt and moisture.

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DEEP SPACE EXPLORER™

Incredible Value!

Shown with optional finder scopes

The 6" model is the ideal beginner's or family scope - and is incredibly low-priced. Weighing only 29 lbs. complete, it's easily moved or handled by anyone. The 8" model offers 77% more light grasp, but is still a reasonable 39 lbs. and is only slightly larger.

The 10" and 12.5" models are perfect for those who can observe from darker sky locations. While heavier and larger than the smaller models at 68 and 85 lbs., they offer tremendous performance for their low prices.

MONEY BACK
If you are not completely satisfied with your purchase from Orion, for any reason,
100% SATISFACTION
Just return it in new condition within 30 days after delivery for a full refund.
GUARANTEE

Call Toll-Free 800-447-1001

Huge Selection of Astronomy Binoculars

50mm Orion Observer™ II Binoculars — 7x, 10x, & 12x

Fine quality, moderately priced binoculars, excellent for both astronomy and daytime observation. Fully coated optics, unique hand strap for a secure and comfortable grip. Include case and straps.

7x50 #9643 **$89.50** (4.44)
10x50 WA #9644 **$94.50** (4.44)
12x50 WA #9645 **$99.50** (4.44)

50mm Explorer™ Binoculars

High performance large diameter binoculars with BAK-4 prisms and multi-coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design. Include case and straps

7x50 #9306 **$117** (4.44)
10x50 #9308 **$127** (4.44)

New! 10x50 Orion UltraView™

The perfect binocular for eye and sunglass wearers. Extra-long 22mm eye relief and unique rubber pop-down eyepiece guard allows viewing with or without eyeglasses. Fully multi-coated optics provide high light transmission and maximum contrast compared to standard coated types. BAK-4 prisms. Wide 6.5° field of view. Close focus 16'. Weighs 32 oz. Includes case and straps.

#9351 **$159** (4.95)

New! 10x50mm Orion Vista™

Superb for long distance nature observation and astronomy. The image quality will amaze you even when compared to much higher priced binoculars. Fully multi-coated optics provide high-fidelity true color images without ghousting or other aberrations. Long 16mm eye relief and roll-back eyecups for eyeglass wearers. BAK-4 prisms. 5.3° field of view. Weighs just 28 oz. Includes deluxe hard carrying case, rain shield, lens caps, and straps.

#9353 **$219** (5.19)

Orion® 70mm FMC Giants

The standard for hand-holdable astronomy binoculars. Fully Multi-Coated. 33% lighter—weighs only 58 oz.—yet the same brightness and 7mm exit pupil as our 11x80 MC model. Superior 'BCF' body design. Includes: soft rubber eyecaps, tripod mounting adapter, durable hard carrying case, lens caps and straps.

10x70 #9501 **Sale! $277** (6.97)
14X70 #9594 **Sale! $288** (6.97)

80mm FMC Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest field available. Ideal for deep-space observation under dark skies. Handholdable. #9502 **$379** (8.05)

16x80 MC- 45% higher power, excellent for astronomy and daytime observation. Tripod recommended. #9496 **$389** (8.05)

20x80 MC- Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required. #9498 **$399** (8.05)

Orion® 8x56 Mini Giants

56mm objective lenses gather over 2.5x the light of ordinary 7x35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view. Standard model 33 oz. Rubber Armored for protection from bumps. Weighs 37 oz.

Standard Model #9504 **$159** (4.71)
Rubber Armored Model #9627 **$159** (5.07)

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

14x100 #9495 **Sale! $777** (29.00)
25x100 #9497 **$899** (29.00)
Shipped by FedEx only.

Observing Aids

NEW! Eyepiece/Accessory Cases

With patented unbreakable latches, die-cut foam inserts.
Inside Dimensions shown
11"x7"x3" #5951 **$17.95** (2.78)
12.5"x9"x5" #5952 **$26.95** (3.36)
16"x11"x5" #5953 **$49.95** (5.19)

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers —fit all Meade & Celestron 8" SCs
DC #3503, AC #3504 **$44.95** (2.98)
10" Dew Zappers—fit all Meade 10" SCs
DC #3506, AC #3508 **$49.95** (2.98)
11" Dew Zappers—fit all Celestron 11" SCs
DC #3510, AC #3512 **$54.95** (2.98)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.

8" Celestron/Meade SC #4200 **$42.95** (2.98)

Other sizes available for scopes 3.5" to 14" —See our catalog for details

Scope Saver Telescope Covers

Keep the dust and dew away with these waterproof nylon covers; drawstring closure with cord lock.

8"Model
#15130 **$33.95** (2.43)
10"-11" Model Fits Meade 10" and Celestron 11"
#15131 **$39.95** (2.43)

Now available for Deep Space Explorers!

Ask about other sizes.

Components

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors
Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors
Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis. *See catalog for pricing.*

Finder Scopes New!

These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube.

6x30mm — Same unit used on $1000+ "big name" telescopes. With 2-ring bracket, fits scopes 6"-12".
#13023 (white) **$44.95** (3.41)

6x30mm Right Angle — 90° prism for right-angle viewing. Includes bracket. #13021 (white) **$59.95** (3.41)

8x50mm—2.7x light grasp of 30mm models. Bright 6.25mm exit pupil. #7090 (white) #7094 (black) **$64.50** (3.41)

8x50mm Illuminated—Wireless illuminator with adjustable brightness. #7092 (white) #7096 (black) **$94.50** (3.41)

9x60mm — 44% more light grasp than 50mm models. #7091 (white) #7095 (black) **$99.50** (3.41)

9x60mm Illuminated—Wireless illuminator with adjustable brightness. #7093 (white) #7097 (black) **$134.50** (3.41)

Mounting Brackets - Unique sliding dovetail design. Super high quality. Fits any scope 6" and over including Celestron & Meade SCs.

8x50mm bracket #5040 **$29.95** (2.98)
9x60mm bracket #5041 **$34.95** (2.98)

Rack-and-Pinion Focusers

Finest in their class. Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.

1.25" #13007 **$49.95** (2.98)

2.0" includes 1.25" adapter.
#13003 **$89.95** (3.95)

NEW! Low-Profile Focusers

Perfect for fast optical systems. Ideal replacements for "Odyssey" scopes.

1.25"-#13014 **$39.50** (2.45)
2.0" - #13016 **$59.50** (2.98)

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection.

Astronomer's Flashlight
#5701 **$9.95** (1.79)
Nitewriter Pen #5709 **$8.95** (1.79)
Hands-Free Flex Light #5707 **$17.95** (2.43)
Starlite LED Flashlight #5714 **$24.95** (2.43)
Celestron LED Flashlight #5720 **$21.95** (2.43)

Observer's Chairs

Standard Model—Adjustable height center column and padded seat.
#5935 **$39.95** (4.70)

Deluxe Model—Built for professional musicians. Extra heavy duty.
#5934 **$89.95** (8.02)

Accessories See Our Catalog for Even More!

45° Erect Image Diagonal Prisms

See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.

1.25" Diagonal #8790
.965" Diagonal #8791
Hybrid 1.25"/.965" Diagonal #8792
$44.95 (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagon let you view at a right ang from the direction you telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.

1.25" Star Diagonal
#8763 **$46.95** (2.98)

Hybrid 1.25"/.965" Star Diagonal
#14008 **$31.50** (2.98)

.965" Star Diagonal
#8761 **$28.95** (2.98)

2" Prism/Mirror Diagonals

2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.
For refractors #8770
For Schmidt-Cass. #8771

$199 ea. (4.71)

2" Mirror Diagonal– Affordable, high-quality star diagonal.
For refractors #8773
For Schmidt-Cass. #8772 **$99.95 ea.** (3.45)

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.

.965" #5268 **$26.95** (2.98)
1.25" #5264 **$28.50** (2.98)
Hybrid 1.25"/.965" #8782 **$28.50** (2.98)

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.
#5262 **$38.50** (2.98)

Tele-Extenders

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.
Standard Tele-Extender #5125 **$27.95** (2.98)
Variable Tele-Extender #5127 **$37.95** (2.98)

T-Adapters

Threads to rear cell of telescope, requires t-ring for your camera model.
for SC #5116 **$26.50** (2.98)
for C-90 #7115 **$29.95** (2.98)

T-Rings

Available for many different camera types, call toll-free or see our catalog for your particular model.

Multi-Function Focal Tester

Allows easy, accurate, ultra-sharp focusing, essential for astrophotography.
#7109 **$169** (4.19)

Tripods

Bogen/Velbon/more!
Huge selection of tripods available, for telescopes, spotting scopes and giant binoculars. Choose from assembled models or mix-and-match pan heads and tripods, sold separately. See our catalog for details.

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.
#7012 **$ 44.50** (2.98)

Extension Cable for Slow Motion Control

12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.
#5014 **$15.95 ea.** (2.43)

StereoScope Viewer

For comfortable two-eyes-open observing. You won't believe the views! Threads securely to the rear cell of your telescope. Requires two identical eyepieces.
#9720 **$479** (5.71)

f/6.3 Reducer/Corrector

Get f/6.3 performance from your f/10 Schmidt-Cassegrain.
#5120 **$169** (3.67)

NEW Model 3

Sky Wizard™

Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

- Find any celestial subject in 15 seconds!
- One minute setup —no polar alignment or levelling.
- Observe hundreds of objects in a few hours!
- For ANY telescope, with or without a motor drive. *Even altazimuth or Dobsonian scopes!*
- Digital display of celestial coordinates (RA & Dec).
- Built-in electronic sky catalog — find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Complete system requires Sky Wizard Model 1 or 2 and a telescope installation package, sold separately.

Encoders and cables available separately for custom installations. Call for details.

Sky Wizard Model 1
Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets.
#7801 **$199** (4.11)

Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice.
#7802 **$319** (4.44)

Sky Wizard Model 3
Gigantic 10,000 object database, expanded subject descriptions, RS-232 port.
#7803 **$469** (6.78)

Installation Packages
Includes 2 encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions.

Celestron Super Polaris	#27100	**$207** (5.29)
Celestron Ultima 8" & 11"	#27101	**$177** (5.29)
Celestron Great Polaris	#10303	**$314** (5.29)
Celestron C-5	#10304	**$298** (5.29)
Celestron G-11	#10305	**$329** (5.29)
Celestron Classic 8" & Powerstar 8"	#27102	**$177** (5.29)
Meade 8" & 10"	#27103	**$202** (5.29)

Dobsonian (fits Coulter and most others)
Call for stock # for your model **$177** (5.29)

Installation packages available for other telescopes.

Orion Off-Axis Guider

Allows you to observe a guide star during photography. Multi-coated.
#5144 **$69.50** (3.45)

Orion UltraGuider

Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.
#5139 **$119** (4.19)

110v Motor Drive for Refractors

Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.
#17001 **$72.50** (3.95)

12 Amp Hour Porta Pac Battery

Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.
#2354 **$109** (8.97)

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.
For 8" SCs #7713 **$144** (4.05)
For 10" SCs #7715 **$162** (4.05)

NEW! *Solar glass filters for Deep Space Explorer reflectors. Many other sizes available—see our free catalog for details.*

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.
.965" #5664, 1.25" #5662 **$14.95 ea.** (2.43)

Color Eyepiece Filters

Highest quality precision-ground optical glass. Fully anti-reflective coated. Solar system observations are dramatically improved. Thread into the barrel of any standard eyepiece, or directly into a universal camera adapter.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow #5510 **$46.95 set** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow. #5514*
1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue. #5516*
1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green. #5570*
$46.95 each set (2.98)

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets.
#5517 **$79.95 set** (3.45)

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set.
#5575 **$119 set** (3.67)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow.
#5513 **$84.95 set** (3.96)

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

Enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow absorbs frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum, yielding dramatic results.

SkyGlow Broadband Filters—Photographic and Visual
For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces.
#5660 **$69.95** (3.45)

SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes.
#5658 **$89.95** (3.45)

52mm Broadband Filter–For 52mm camera lenses, (Adapter rings available for other diameters.)
#5668 **$87.50** (3.45)

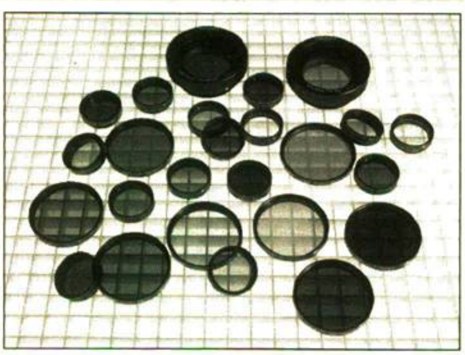
2.0" Broadband Filter–fits 2" eyepieces.
#5659 **$109** (3.45)

.965" Broadband Filter–fits .965" eyepieces.
#5661 **$49.95** (2.98)

SkyGlow UltraBlock Filters–Visual Only
For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces.
#5654 **$87.50** (3.45)

SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes.
#5656 **$119** (3.67)



Eyepieces & Barlows

✧ *Sirius*™ Plössl 1.25" Eyepieces

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

You could pay nearly twice the price for 'famous name' Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces!

Sirius Plössls are top-quality, 50° apparent field eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of reflector, refractor and catadioptric telescopes. The Plössl design is renowned for its fantastic performance and has in recent years become the standard by which all other eyepieces are compared.

Each eyepiece is of the classic 4-element Plössl design. Every air-to-glass surface is fully Magnesium Fluoride anti-reflection coated. All lens edges are blackened in the same way as expensive military optics, to further eliminate any scattering of stray light and to maximize contrast.

The optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

We guarantee you'll be impressed with the performance of the Sirius Plössls, even when compared to the more expensive name-brand Plössls.

25mm #8530, *17mm* #8531, *10mm* #8532, *7.5mm* #8533 **$59.95 each** (3.45)

Special Savings-Buy 2 or more & get case free!

Any 2	*$54.50 ea.*	*SAVE $23.95*
Any 3	*$48.00 ea.*	*SAVE $48.80*
All 4	*$44.00 ea.*	*SAVE $76.75*

Case only #5911 **$12.95** (2.19)

Explorer .965" & 1.25" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated, to maximize efficiency in the various focal lengths. Black anodized, internally blackened, threaded for filters (except 40mm .965").

.965 Orthoscopic
5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583 **$49.50 each** (2.98)

.965 Kellner
18mm #8584, **25mm** #8585
$37.50 each (2.98)

.965 Achromatic Huygenian
40mm #8586
$37.50 (2.98)

1.25" Orthoscopic
5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526
$54.50 each (2.98)

1.25" Kellner
6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512
$39.50 each (2.98)

Superb Ultrascopic™ Eyepieces

Unlike other premium eyepieces, Orion Ultrascopics offer complete multi-layer coatings on ALL surfaces, for superior light transmission and contrast. Modern 5- and 7- element designs for pinpoint star images and breathtaking detail. Wide 52° field of view. Guaranteed to beat other brands selling for much more! Unsurpassed high-performance design!

Medium-High Power 5-element
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 **$74.95 ea.** (3.45)

Wide Field 5-element
25mm #8564 **$89.95** (3.45)
30mm #8562 **$94.95** (3.45)
35mm #8560 **$99.95** (3.45)

***High Power 7-element** —Long Eye Relief*
5mm #8574, **3.8mm** #8576 **$84.95** (3.45)

MegaVista 1.25" & 2" Eyepieces

These outstanding eyepieces feature a 7-element design and incredibly sharp, fully multi-coated optics. The long eye relief and integral rubber eyeguards make these ideal for eyeglass wearers. The extra wide field of view (67°-70°) provides stunning images, perfect for deep space observing.

10.5mm 1.25" #8552 **$164** (3.67)
16.8mm 1.25" #8554 **$159** (3.67)
34mm 2" #8587 **$209** (3.67)
40mm 2" #8588 **$229** (3.67)

Illuminated Reticle Eyepieces

Orion offers 4 versions of the illuminated reticle eyepiece, a necessity for long exposure astrophotography and very useful for polar alignment. All have 1.25" barrels.

12.5mm Plossl Illuminated Reticle
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 **$109** (3.45)

12mm Kellner Illuminated Reticle
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 **$79.95** (3.45)

9mm Orthoscopic Illuminated Reticle
Adjustable brightness illuminator. 'Bull's-eye within crosshairs' reticle. Needs 2 SR-44 batteries, not included.
#8488 **$109** (3.67)

6mm Orthoscopic Illuminated Reticle
Unique adjustable reticle system. Variable brightness. Needs 2 SR-44 batteries, not included.
#8487 **$129** (3.67)

SR-44 Batteries #2360 **2 for $5.69** (1.79)

UltraZoom™ 7–21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.
#8556 **$159** (3.67)

See our free catalog for a fantastic selection of name-brand eyepieces!

CELESTRON Tele Vue

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.
.965" #8740 **$34.95** (2.98)
1.25" #8746 **$44.95** (2.98)
2" #8724 **$89.95** (3.95)

Ultrascopic 2x Fully Multi-Coated Barlow
3-element Ultrascopic lens for superior images and precise color correction. Fully multi-coated optics, black anodized barrel. 1.25 barrel.
#8750 **$64.95** (3.45)

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 **$59.95** (3.45)

Shorty Barlows

The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly, and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.
.965" #8710 **$46.95** (2.98)
1.25" #8711 **$54.95** (3.45)

Phone Your Order in by December 23rd for Express Delivery of In-Stock items by Christmas Eve!

IT'S EASY TO ORDER!

- Call Toll-Free and charge to your MasterCard, Visa or Discover Card or send your personal check to order by mail.
- California residents add 7.25% sales tax (8.25% in Santa Clara and Santa Cruz Counties, 8.5% in San Francisco).
- Shipping & handling charge for UPS Ground or US Mail to lower 48 United States are listed in (parentheses) after each price. We ship to U.S. and Canada only.
- We expected the prices in this ad to be accurate for December 1993 at the time of our advertising deadline in September. Prices are subject to change or correction without notice.

MasterCard DISCOVER VISA

ORION
TELESCOPE CENTER
2450 17th Ave., P.O. Box 1158-A
Santa Cruz, CA 95061-1158
When ordering, mention key code JMA
Business Offices (408) 464-0446

Orion Accessories
Orion accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with "famous name" products! We buy direct from many of the same sources, always specify the highest quality, and pass along the savings to you! 100% satisfaction guaranteed!
#1 for Quality
#1 for Value

SKY ALMANAC

January 1994

• Saturn Well Placed for Viewing

The Ringed Planet lingers in the evening sky this month before slipping into invisibility in February. Look toward the southwest shortly after dusk to see Saturn, which outshines all the stars surrounding it. Telescopes show the planet's golden rings, the dusky polar region, and the planet's shadow cast onto the rings.

• Quadrantid Meteors Peak

Although a Last Quarter Moon will mar viewing the Quadrantids' peak on January 3, enough meteors will be visible before moonrise to warrant your attention. Look for at least several dozen meteors per hour originating from a point in Bootes.

• Periodic Comets Brighten

Two bright comets return to easy visibility this month. Comet Schwassmann-Wachmann 2 glides past the Beehive Cluster in Cancer, shining at 11th magnitude. Tenth-magnitude Comet Encke wanders through Pegasus this month.

• Morning Pairing of Moon and Jupiter

On January 6 look for a conjunction between the Moon and Jupiter in the early morning sky, just before dawn. Face due south and you'll see these two, the brightest objects in the sky, along with the nearby stars Zubenelgenubi and Zubeneschamali in Libra.

• Observe the Killer Comet

Fragmented Comet Shoemaker-Levy 9 is headed for a collision with Jupiter this July. As Jupiter becomes visible in the morning sky this month you can begin monitoring the comet, which glows feebly at 14th magnitude and is pacing Jupiter's motion. The two objects are now separated by about 2°.

LEO MINOR
LEO
CANCER
M44
HYDRA
Procyon
CANIS MINOR
M47
PUPPIS
Adhara

CALENDAR OF EVENTS

2 Earth is at perihelion (91,403,000 miles from the Sun), 1 a.m. EST

3 Mercury is at superior conjunction, 3 p.m. EST

4 Last Quarter Moon is at 7:00 p.m. EST

5 The Moon passes 1.2° south of Spica, noon EST
The Moon is at perigee (229,995 miles from Earth), 8 p.m. EST

6 The Moon passes 3° south of Jupiter, 5 p.m. EST

11 Neptune is in conjunction with the Sun, 12 EST
New Moon is at 6:10 p.m. EST

14 The Moon passes 7° north of Saturn, 7 p.m. EST

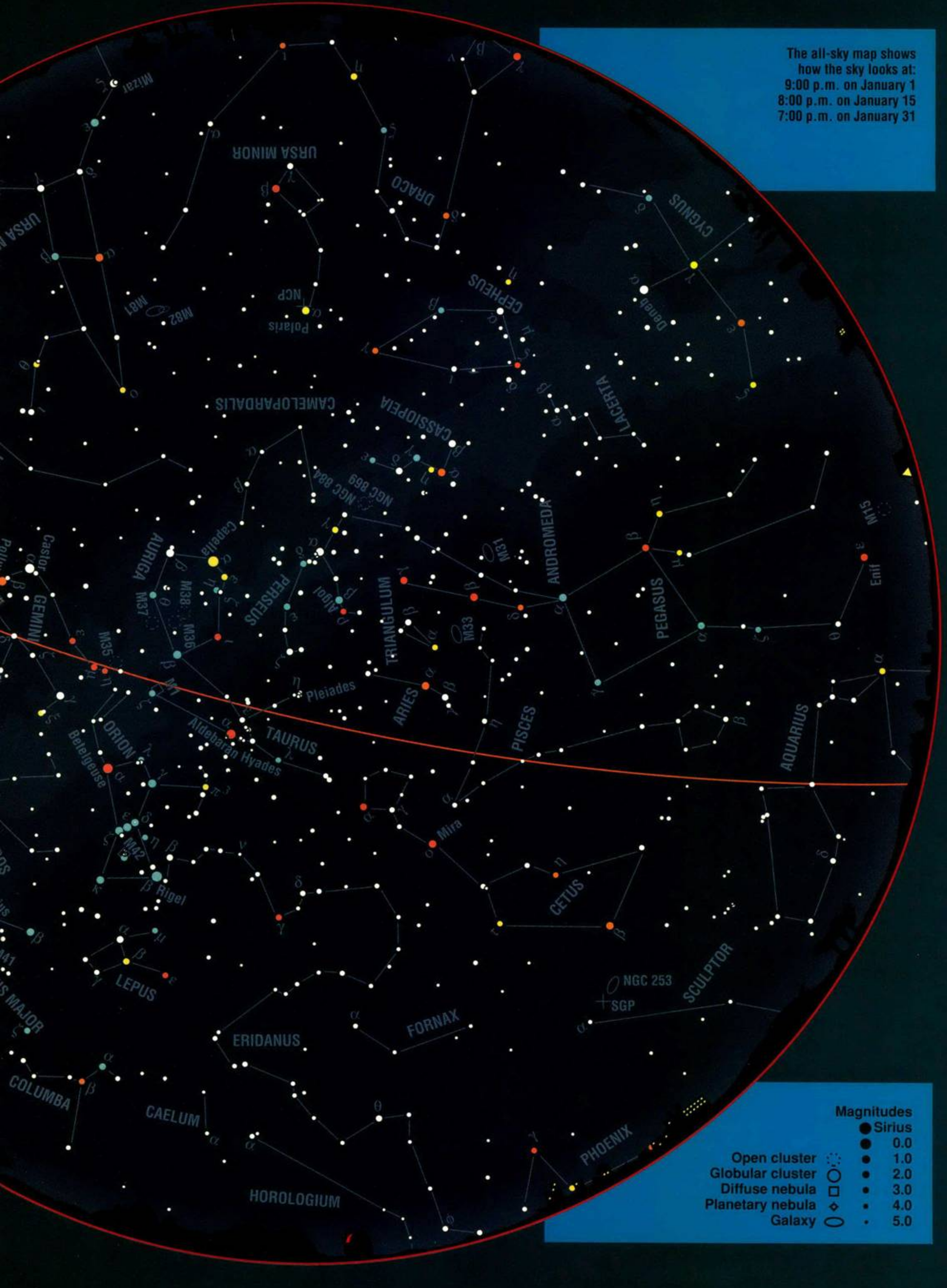
16 Venus is at superior conjunction, 9 p.m. EST

19 The Moon is at apogee (251,258 miles from Earth), midnight EST
First Quarter Moon is at 3:27 p.m. EST

27 Full Moon is at 8:23 a.m. EST

30 The Moon is at perigee (228,296 miles from Earth), 11 p.m. EST

The all-sky map shows
how the sky looks at:
9:00 p.m. on January 1
8:00 p.m. on January 15
7:00 p.m. on January 31


Mizar
URSA MINOR
DRACO
CYGNUS
URSA M
M81
M82
NCP
Polaris
CEPHEUS
Deneb
CAMELOPARDALIS
CASSIOPEIA
LACERTA
NGC 869
NGC 884
Capella
AURIGA
Castor
Pollu
GEMINI
M37
M38
M36
M35
PERSEUS
Algol
TRIANGULUM
M31
ANDROMEDA
M33
PEGASUS
M15
Enif
Pleiades
ARIES
PISCES
AQUARIUS
ORION
Betelgeuse
Aldebaran
Hyades
TAURUS
Mira
M42
Rigel
CETUS
LEPUS
S MAJOR
NGC 253
SGP
SCULPTOR
FORNAX
ERIDANUS
COLUMBA
CAELUM
HOROLOGIUM
PHOENIX
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

SKY ALMANAC

by Deborah Byrd and Jeff Kanipe

Last August's Perseid meteor shower delighted everyone who saw it. The event aptly represented the fickle nature of meteor showers: Professional astronomers suggested a storm of activity might occur, but it didn't. However, the lucky souls who ventured outside watched an unusually high number of bright meteors zip overhead. Although this month's Quadrantid meteor shower can't match the activity of the Perseids, it still provides a good show for those who bundle up and head out under the cold evening sky of winter.

The Quadrantids are named for the defunct constellation Quadrans Muralis, or Wall Quadrant, which represented an early astronomical device used for measuring angles. The shower peaks on January 3. The Quadrantids have a very narrow peak that lasts only a couple of hours. And, unfortunately, this year a Last Quarter Moon will interfere somewhat with viewing meteors in the early morning hours.

Don't let this stop you, however. This year the radiant, the point from which the meteors appear to originate, is up earlier than the Moon. This means that a good number of meteors ought to be visible before the Moon rises. You might try watching fairly early in the evening on January 2 or in moonlight on the morning of January 3. Be sure to watch for an hour or more far away from city lights.

Only one planet currently graces the evening sky, Saturn. Look for it low in the southwest not long after darkness falls. This bright planet is the best telescopic sight in the solar system. Though Saturn is a dot of light to the naked eye, when you view it through a telescope you'll see a large, cream-colored ball encircled by glorious rings.

To the eye, Saturn appears as a steady light. It has been a quiet companion to the evening stars for many months. Now it is about to pass behind the Sun from Earth. Because it is near the Sun along our line of sight, it does not spend many hours shining at night. The planet sets about three hours after sunset in early January and just over an hour after sunset by month's end.

Look for Saturn on the evenings of January 13 and 14, when it is the closest bright object to the Moon. The bright star nearby is Fomalhaut in the constellation Piscis Austrinus the Southern Fish. Just before the month ends, as the bright evening twilight is about to swallow Saturn, Mercury passes close to the Ringed Planet. This occurs low in the southwest after sunset. You may wish to use binoculars to follow this event.

About an hour before sunrise on January 6, look nearly due south to see Jupiter and the Moon, the two brightest objects in the sky. Look east of these beacons and you'll see the two brightest stars in Libra, Zubenelgenubi (Alpha Librae) and Zubeneschamali (Beta Librae). The Arabic names of these stars translate to Southern Claw and Northern Claw. They date back to a time when Libra's stars were considered part of the constellation Scorpius the Scorpion.

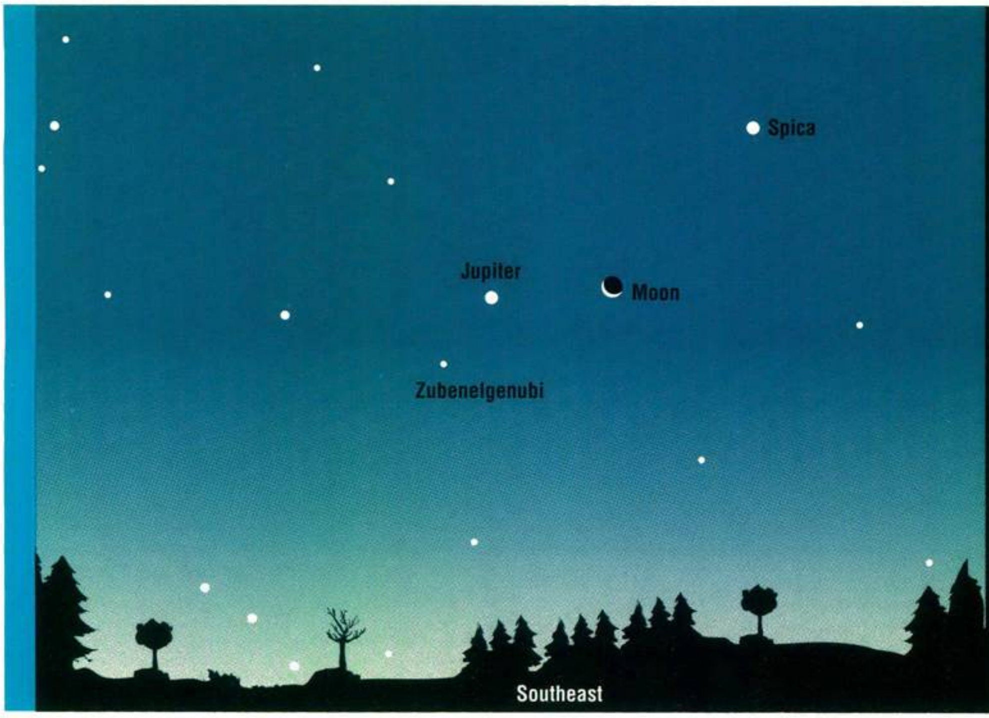
Zubenelgenubi is a widely separated double star. Both components of this system are visible with your binoculars or a small telescope. Zubeneschamali is one of the

Charles Capen

The Beauty of Saturn

Though it is approaching conjunction with the Sun late next month, the planet Saturn remains a showcase telescopic object in the western evening sky. Saturn's most obvious feature, its ring system, is just discernible in binoculars. But a low-power telescope reveals a bright, cream-colored ball set within the sharp-edged, oval-looking rings — unmistakable proof that you're looking at a three-dimensional object.

Although seeing conditions and optics vary, viewing fine detail such as belts, eruptions, and ring gaps generally requires magnifications between 150x and 300x and a minimum aperture of four inches. Look for the angular-shaped shadow of the ball cast across the rings running behind the planet, the dusky polar region and bright equatorial zone, and variations in the shape and intensity of the North Equatorial Belt. Look especially for possible eruptions that will occur within the equatorial, tropic, and temperate zones. Saturn never fails to please, or surprise, in the eyepiece.



A Striking Conjunction at Dawn

According to ancient Hindu lore, the stars Zubenelgenubi (Alpha Librae) and its northeastern neighbor, Zubeneschamali (Beta Librae), represented a celestial gateway because the Sun, Moon, and planets often pass between them as they move through the zodiac.

This seems to be the case the mornings of January 6 and 7 as the waning crescent Moon slips past Jupiter and through the "gate" near Zubenelgenubi. On January 6, the Moon lies northwest of Jupiter; the next morning, it lies southeast of Jupiter and about 5° northeast of Zubenelgenubi. A pretty composition awaits you on both mornings.

only stars in the heavens sometimes said to appear green. Astronomers say stars can't look green — the spectrum of star colors does not include this color. You may want to judge for yourself using a telescope. During the daytime of January 6, the Moon passes between these two stars, which in skylore represent a gate because the Moon and planets sometimes pass through. Throughout January Jupiter edges northwest of Zubenelgenubi, and by month's end the two objects are separated by less than 2°.

Planets aren't the only wanderers this month, however. On January 1, 1801 — during the first night of the nineteenth century — Giuseppe Piazzi peered through his telescope and discovered the first known asteroid, Ceres. You can celebrate the anniversary this month by tracking the fifty-second asteroid, Europa. It is in a good object to observe, coming to opposition on January 27. At about 10th-magnitude, Europa is not visible to the eye alone, but a small telescope reveals its starlike glow.

The name *asteroid* means "starlike." At first glance, your telescope will show no difference between an

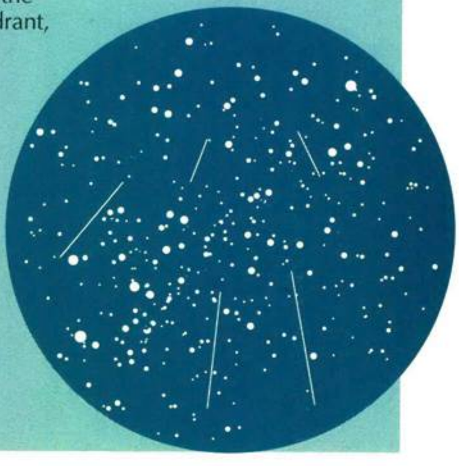
Gert Kroner

Quadrantid Meteors Visible

This shower peaks on the morning of January 3 and is active during the year's first five days. Look east of the handle of the Big Dipper in northeastern Bootes. (Bootes, Draco, and Hercules contain parts of the ancient constellation Quadrans Muralis, or Wall Quadrant, named for an instrument used for measuring angular distances.) The radiant, or point where the meteors appear to originate, is near the northern horizon at about 9 p.m. but is well up by midnight.

Quadrantid meteors, those produced by the current shower, are bluish in color and usually quite faint. The average hourly rate of meteors at the zenith for the Quadrantids is 110, although observers have reported seeing as many as 250 and as few as a dozen Quadrantids per hour. The all-sky map at right shows the sky and the paths of meteors in the early evening sky of January 3.

This year, the Last Quarter Moon interferes somewhat with seeing the fainter meteors in the morning sky.

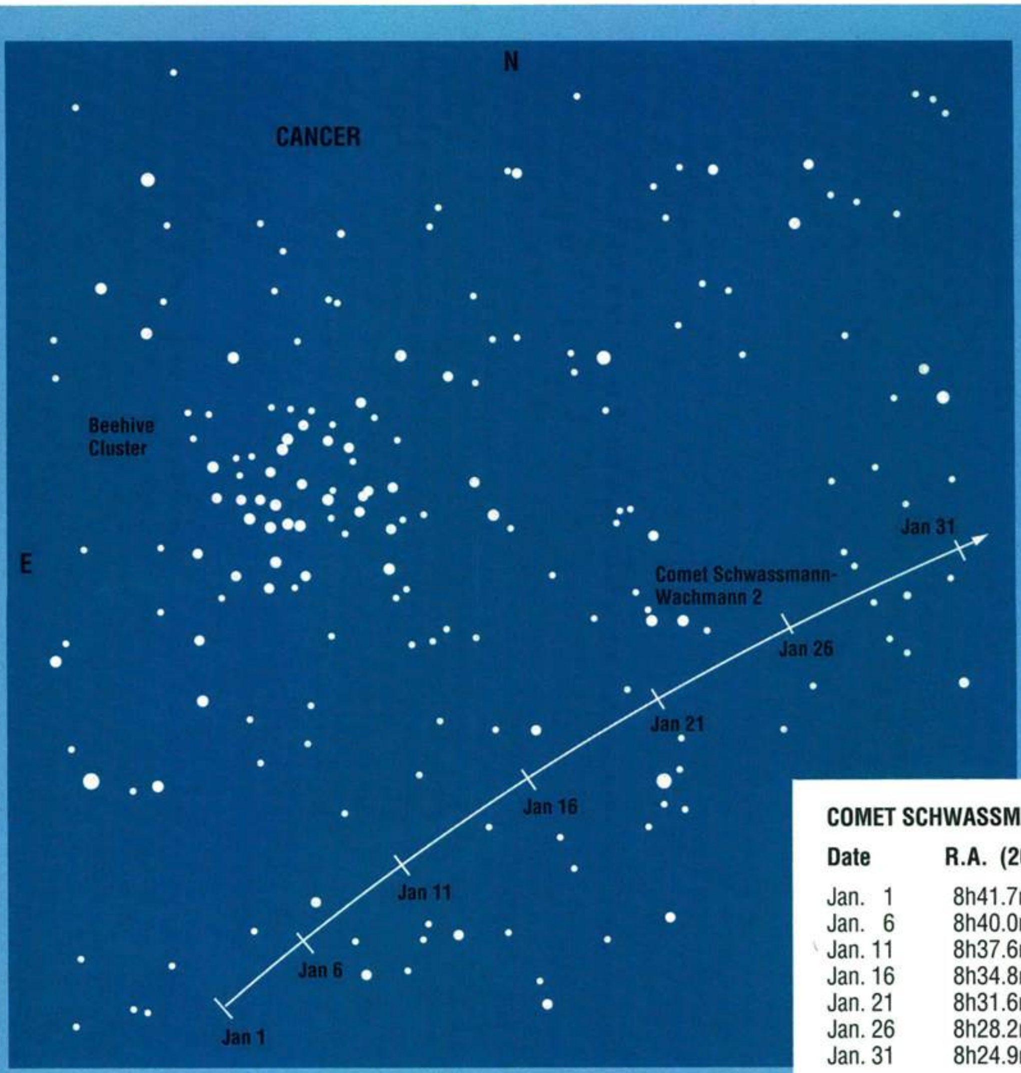


asteroid and a star. In reality, the difference is great: Stars glow by nuclear fusion while asteroids are simply pieces of rock reflecting light from our star, the Sun. Asteroids are vastly closer to us than stars and are orbiting the Sun, so they appear to move relative to the stars. As stars move across our sky we are seeing motion caused by Earth's rotation. But the asteroids are close enough to move not only because of Earth's rotation but because of their own orbits around the Sun, and this difference causes them to shift positions relative to the stars. This effect can be visible over time spans as short as hours. To find 52 Europa, check the finder map on page 55. If you're not sure which object is the asteroid, draw all the stars in the appropriate field. A night or so later, one "star" will have moved, Europa.

Their different motions and also a distinctly nebulous glow set the comets apart from stars. The periodic comets Schwassmann-Wachmann 2 and Encke are possible targets for your binoculars or telescope this month. Such comets brighten to visibility every few years as they come in close to the Sun. If you have trouble finding them, try using averted vision, peeking out of the corner of your eye. This technique uses your eye's rods, which are best at seeing faint light.

Lastly, don't forget simply to stand out under the stars this month, gazing upward, enjoying the character of the winter sky. In contrast to the sublime haziness of the stars on late summer evenings, the winter stars have a crisp, distinct look. These stars

(continued on page 56)



COMET SCHWASSMANN-WACHMANN 2

Date	R.A. (2000)	Dec.	Mag.
Jan. 1	8h41.7m	16°58'	11.5
Jan. 6	8h40.0m	17°17'	11.4
Jan. 11	8h37.6m	17°40'	11.4
Jan. 16	8h34.8m	18°04'	11.4
Jan. 21	8h31.6m	18°31'	11.3
Jan. 26	8h28.2m	18°58'	11.3
Jan. 31	8h24.9m	19°24'	11.3

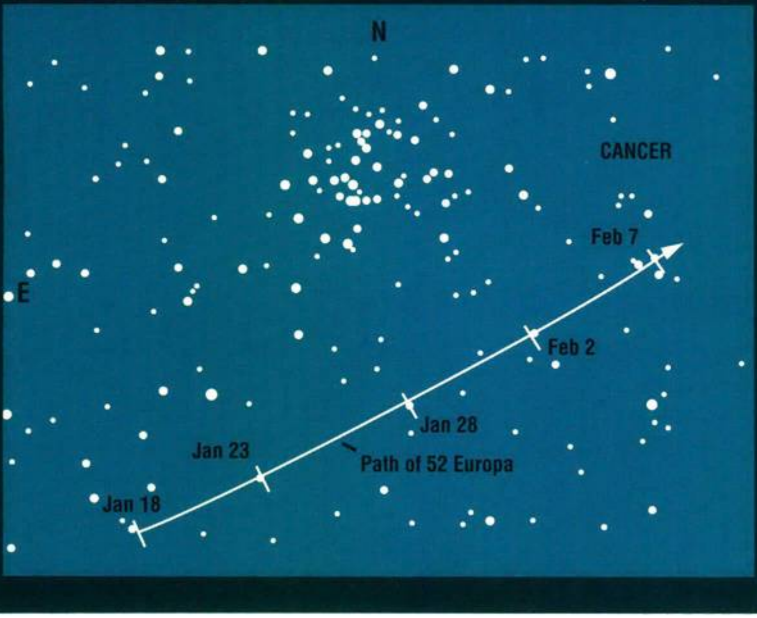
Comet Schwassmann-Wachmann 2 Returns

Comet Schwassmann-Wachmann 2 is well placed in the eastern evening sky by 9 p.m., tracking through barren Cancer and heading, more or less, in the direction of Castor and Pollux. During the first half of the month, the comet passes southwest of the Beehive Cluster, M44 (it is closest between the 11th and 16th), when it should make a fine composition for wide-angle photography.

This comet doesn't get that bright, though, and at magnitude 11.3 on the 21st, S-W 2 will be tough for telescopes smaller than four inches, unless your skies are dark and clear.

S-W 2 continues moving northward through Cancer next month. By mid-March, it turns around and heads south, but by then it will have faded to magnitude 12. The comet returns to the inner solar system again in the year 2000.

Following 52 Europa



For you asteroid trackers, 52 Europa can be found this month creeping steadily through Cancer near the Beehive Cluster (M44). This 180-mile-diameter chunk of carbonaceous chondrite brightens from magnitude 10.7 on January 4 to 10.3 on January 14 and reaches magnitude 10 by month's end, when it should be an easy target for a 6-inch or larger telescope.

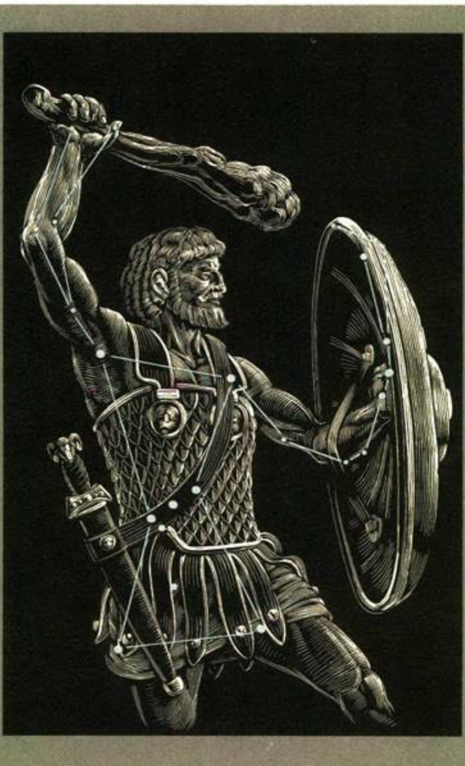
By the way, this region of sky is up virtually all night, so you should be able to follow 52 Europa's progress over periods of several hours as it moves relative to the stars.

ASTEROID 52 EUROPA

Date	R.A. (2000)	Dec.	Mag.
Jan. 18	8h47.2m	17°07'	10.2
Jan. 23	8h43.3m	17°36'	10.1
Jan. 28	8h39.2m	18°05'	9.9
Feb. 2	8h35.1m	18°34'	10.1
Feb. 7	8h31.1m	19°02'	10.3

THE STARRY SKY

by Deborah Byrd



Keith Ward

Look high in the south in mid-evening this month for the constellation Orion, whose distinct pattern and numerous bright stars make it easy to recognize. Orion's two brightest stars, Betelgeuse (Alpha Orionis) and Rigel (Beta Orionis), are located diametrically opposite each other in a large rectangle, on either side of an interior row of three stars.

The red star Betelgeuse marks the Hunter's right shoulder. While distant at 1,400 light-years from us, this star shines brightly at magnitude 0.5. Its spectral class is M2. Now swollen with old age to an enormous size, it is a red supergiant, some 500 times greater in diameter than our Sun.

The star Rigel marks the Hunter's left foot. Also about 1,400 light-years away, it shines at magnitude 0.1. It is a blue supergiant whose spectral class is B8.

The row of three stars inside the rectangle is known as Orion's Belt. From east to west, the Belt stars are Alnitak (Zeta Orionis), Alnilam (Epsilon Orionis), and Mintaka (Delta Orionis). The curved line of stars hanging from the Belt represents Orion's Sword, whose middle "star" is one of the sky's most celebrated objects. This object, which appears fuzzy to the eye, is the Orion Nebula (M42), a luminous region in a great dark cloud where new stars are being born. Be sure to turn your binoculars or a telescope on the nebula.

Our most familiar legends about Orion come from Greek mythology. Legend tells us that the Hunter is the son of Poseidon the Sea God. He was said to be the tallest and most handsome of men, able to stand with his feet on the ocean floor and his head above the waves. According to one story, Orion boasted that no creature on Earth could withstand him, so Hera sent a scorpion to sting and kill him. Accordingly, he does not rise until the constellation Scorpius has set.

In another story, Orion hunted wild beasts in the kingdom of Chios, whose ruler had a beautiful daughter. Orion asked to marry her, but the king did not want such a formidable man for a son-in-law. He tricked Orion into becoming drunk, and then he blinded him. Orion followed the sound of ringing hammers to the blacksmith god Hephaistos. The blacksmith gave the Hunter his assistant, a lame cyclops named Cedalion. Orion carried Cedalion on his shoulders, and Cedalion lent his powerful eye to Orion, ultimately helping him find a land "at the east of east." There the rising Sun healed Orion's eyes.

Orion is also legendary as the hunting companion of the moon-goddess Artemis. Their relationship aroused the jealousy of her twin brother, the Sun-god Apollo. One day Apollo and Artemis stood on a beach, and he challenged her to hit a dark object far away on the sea. This object was Orion's head, visible above the waves as he walked on the ocean floor. Artemis' arrow killed Orion, and to console her, Zeus placed the Hunter among the stars.

seem to shine with a cold light, like glinting icicles hanging from the roof of a vast, dark cavern over our heads. The association of these stars with cold is not universal. The winter stars are not a reflection of Earthly meteorology. Recollect that these same stars are now visible from the Southern Hemisphere, at the height of the austral summer.

January's Planets

Planets are scarce this month. **Mars** was in conjunction with the Sun (traveling behind the Sun as seen from Earth) late last month. It'll be gone from our sky throughout January. Likewise, **Neptune** and **Uranus** are in conjunction with the Sun on January 11 and 12. **Venus** is in superior conjunction on January 17. None of these planets is visible.

Mercury is in superior conjunction — on the far side of the Sun — on January 3. But by late January, it has sped forward in its orbit far enough to become visible low in our southwestern sky after sunset. There it joins the planet Saturn. These two planets will have a conjunction, a close passage near each other, in early February.

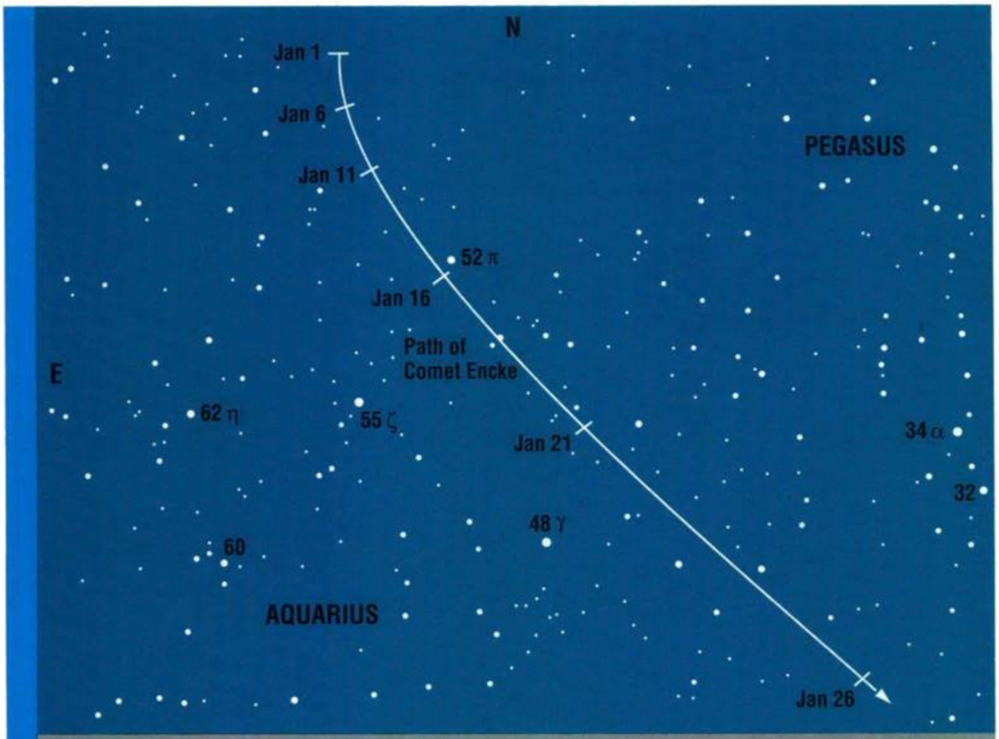
Throughout January, **Saturn** appears in the southwest after sunset, shining at magnitude 0.9 in the constellation Aquarius. In the course of this month, Saturn sinks toward the twilight glare. Try to view Saturn at least one more time. The planet is now low in the sky, so you'll have to peer at it through a great thickness of Earth's atmosphere. Still, even small telescopes reveal the planet's rings and its largest moon, Titan. This moon appears like a pinpoint of light near Saturn.

After Saturn sets, several hours pass each night during which no planets are visible. The spell is broken when **Jupiter** ascends over the eastern horizon. Jupiter comes up five hours before the Sun in early January in the constellation Libra. You cannot mistake the giant planet for any other object: At magnitude –1.9, it outshines all the stars. On January 6 the Moon passes 3° south of Jupiter.

You'll have plenty of time to gaze at this planet in the months ahead, but if you just can't resist turning your telescope on it now, you'll get a good view. Note the planet's squashed appearance, its orbiting moons, and red-and-tan belts of clouds. In mid-July fragmented Comet Shoemaker-Levy 9 will collide with Jupiter, providing us with a unique observing opportunity.

Pluto is in Libra, too. It is rising about four hours before the Sun in early January, but you won't see it without a telescope. Pluto is about a thousand times too faint to be seen with the eye; try at least an 8-inch scope. ☐

Deborah Byrd writes and produces the daily "Earth and Sky" radio series. Jeff Kanipe is the editor of Star Date *magazine and writes an astronomy column for the Associated Press.*



Tracking Comet Encke

One of the brightest periodic comets this year will be Comet Encke. On January 1, the comet will be a 9th-magnitude fuzzball southeast of a compact triangle of 5th- and 6th-magnitude stars, 35, 37, and 34 Pegasi in the bright constellation Pegasus the Winged Horse. This region is a little over 10° southeast of Enif, the bright star marking the noble horse's nose. On January 16 the comet will skim past the bright variable star Pi (π) Aquarii. By the 20th, Encke will be neatly placed between Alpha (α) and Zeta (ζ) Aquarii and, at magnitude 7, an easy object in a telescope or binoculars.

Although Encke *is predicted* to reach a peak magnitude of 4.2 in early February, when it's invisible, all such predictions should be taken with the proverbial grain of salt. According to comet expert Alan Hale of the Space Center in Alamogordo, New Mexico, Encke doesn't brighten predictably as it approaches the Sun. Some comets just don't do what they're supposed to do, but this is one characteristic that makes them worth watching.

Yerkes Observatory

COMET ENCKE

Date	R.A. (2000)	Dec.	Mag.
Jan. 1	22h29.5m	3°23'	9.6
Jan. 6	22h29.2m	2°53'	9.2
Jan. 11	22h28.3m	2°14'	8.7
Jan. 16	22h25.8m	1°17'	8.3
Jan. 21	22h20.4m	–0°12'	7.8
Jan. 26	22h09.5m	–2°42'	7.4
Jan. 31	21h50.1m	–6°49'	7.1

Keeping Tabs on the Killer Comet

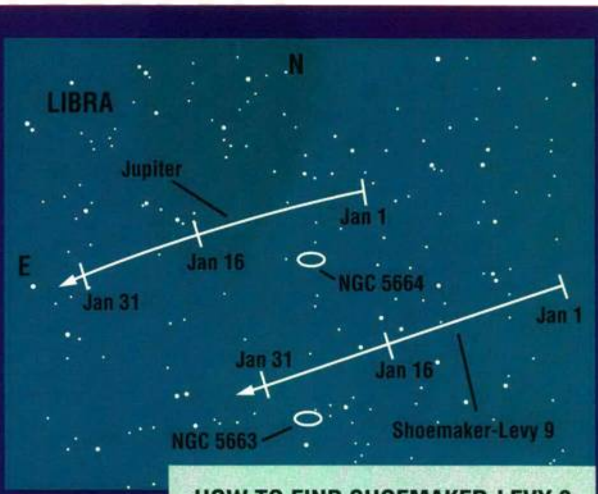
Jupiter is a morning object right now, rising in Libra around 2:30 a.m. early in the month. Just a little over 2° south and west of this morning "star," which translates into nearly 20 million miles at Jupiter's distance, a runaway train of icy fragments from Comet Shoemaker-Levy 9 steadily bears down on the planet. All of these fragments will strike Jupiter in mid-July in what will be the first cometary impact with another planet ever observed.

Unfortunately, the comet train is beyond visual reach right now, unless you have access to dark skies and a large telescope — that is to say, in the 18- to 24-inch class, perhaps equipped with a CCD camera. Technically, the comet's magnitude is around 14, but remember, that's an integrated magnitude — in other words, the visual magnitude it would have if you gathered up its total light and compressed it into a point. But because its light is spread over a large area rather than concentrated into a point, the comet has a low surface brightness and will be more difficult to see than its magnitude suggests.

During early January, the comet can be found in Virgo less than 1° southeast of Lambda Virginis. Then, for the remainder of the month, it hugs the ecliptic as it moves into Libra, heading almost straight for Zubenelgenubi and the gateway to the zodiac. Coordinates for SL-9 that are offsets from Jupiter are given in the box.

We'll be providing ASTRONOMY readers with monthly updates on this event, so be sure to watch these pages.

Jane Luu



HOW TO FIND SHOEMAKER-LEVY 9

On this date	Offset from Jupiter	
	West in R.A.	South in Dec.
Jan. 1	9'29"	1°17'23"
Jan. 6	9'27"	1°18'16"
Jan. 11	9'26"	1°19'07"
Jan. 16	9'25"	1°19'58"
Jan. 21	9'24"	1°20'46"
Jan. 26	9'23"	1°21'28"
Jan. 31	9'22"	1°23'37"

A Binocular Tour of the Hyades

Under a cold, clear winter night, the eye soaks up the sparkling light from the Pleiades and Hyades clusters, which hang in the sky like the brightest baubles on a Christmas tree. Of the two, the Pleiades usually garners the most attention, but don't underestimate the Hyades, a large, bright V-shaped cluster of about 200 stars covering over 5° of sky. You will readily see several fine pairs of stars and at least two open clusters lying near the Hyades in 7x50 or 11x80 binoculars.

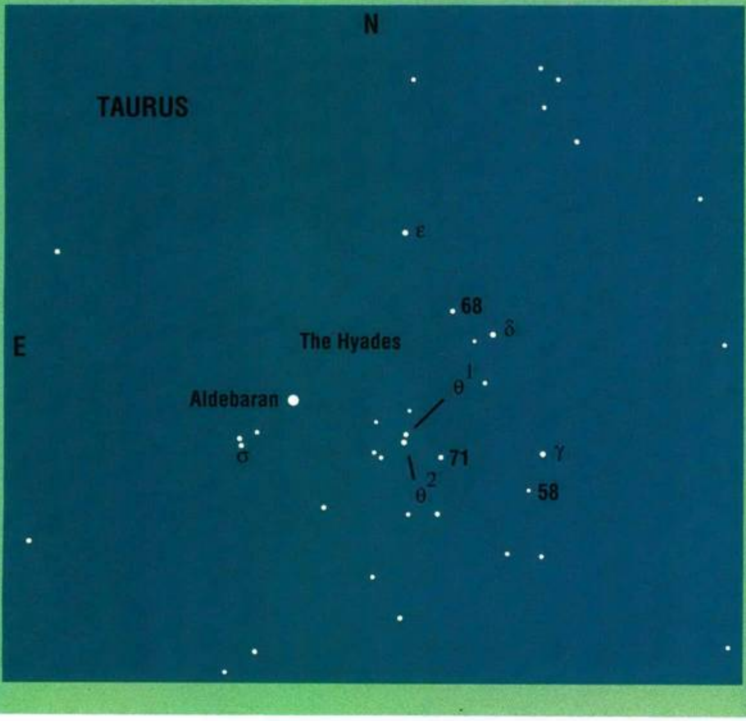
Most prominent is Aldebaran, a red giant that, in fact, is not a member of the Hyades. It is a foreground star, lying only 68 light-years away. Aldebaran has a faint companion star, but you need a large telescope to glimpse it.

Just southwest of Aldebaran, Theta^2 (θ^2) Tauri forms a wide double with Theta^1 (θ^1). The visual magnitudes are 3.4 and 3.9, respectively. In absolute magnitude, its real brightness independent of its distance from us, Theta^2 is one of the brightest stars in the Hyades. Its luminosity is some fifty times that of the Sun.

Sigma (σ) Tauri, just 1° southeast of Aldebaran, is a wide pair of white stars shining at magnitudes 4.7 and 5.1. Only the brighter, more northerly of the pair, however, is a Hyades member.

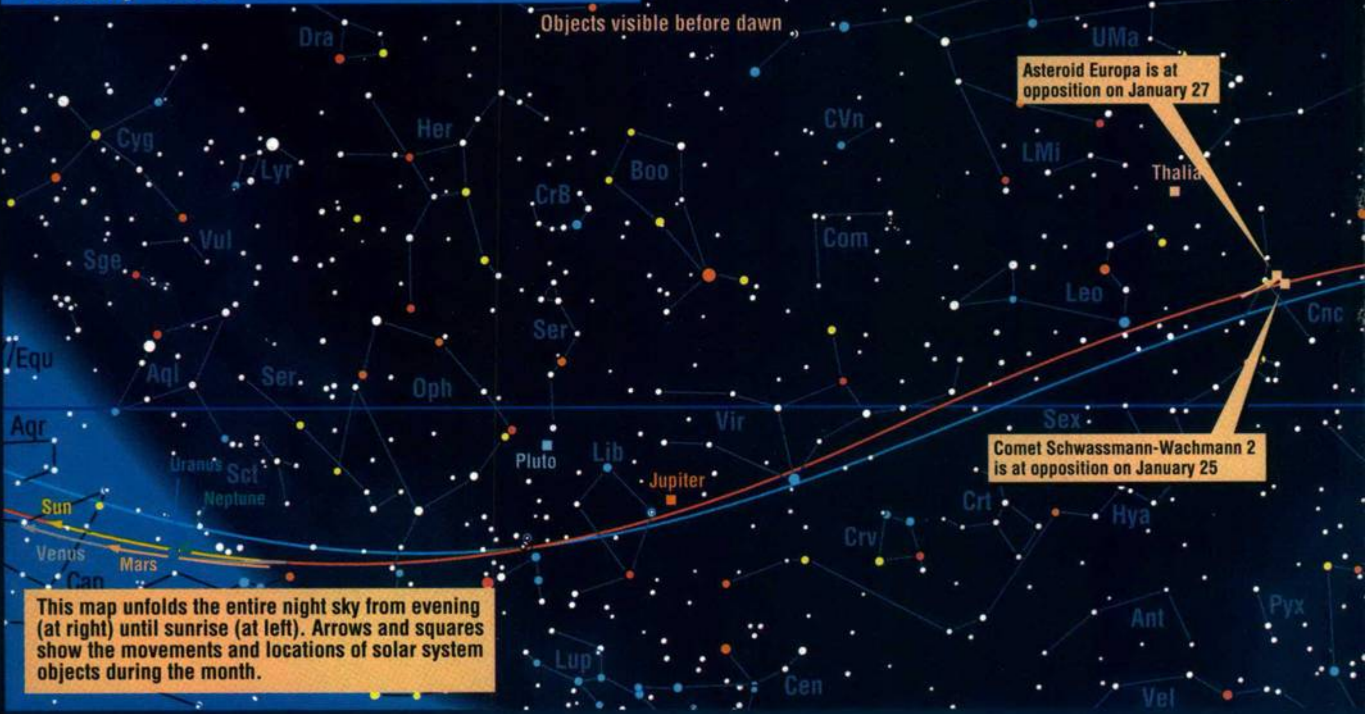
If your skies are dark enough, try looking for NGC 1647, a spherically shaped arrangement of about 200 stars 3.5° northeast of Aldebaran toward Beta (β) Tauri. The open cluster, which is about 45' in diameter, is quite rich in stars, but resolves well in 10x70 or 11x80 binoculars.

Continuing out from Aldebaran on a line toward Beta Tauri, you encounter NGC 1746, a delicate scattering of about fifty or so stars. This open cluster is not as symmetrical as NGC 1647, but it does contain a few bright members that not only outshine those of NGC 1647 but give it the appearance of a smaller number of stars. A pair of 7x50 binoculars easily resolves all the stars in this cluster.



SKY ALMANAC

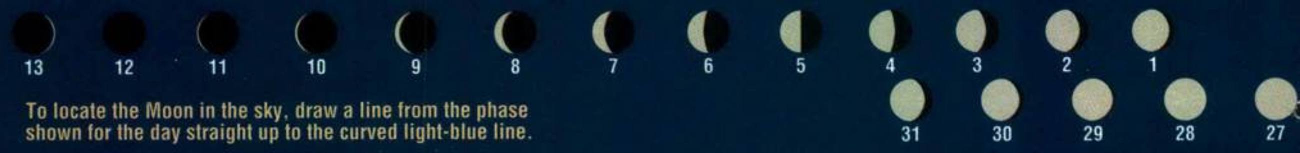
January 1994


Objects visible before dawn
Dra
Cyg
Lyr
Her
CrB
Boo
CVn
UMa
LMi
Thalia
Vul
Sge
Com
Leo
Cnc
Ser
Equ
Aql
Ser
Oph
Aqr
Vir
Sex
Uranus
Sct
Neptune
Pluto
Lib
Jupiter
Sun
Venus
Mars
Cap
Crt
Hya
Crv
Ant
Pyx
Lup
Cen
Vel

Asteroid Europa is at opposition on January 27

Comet Schwassmann-Wachmann 2 is at opposition on January 25

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.


13
12
11
10
9
8
7
6
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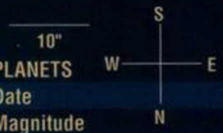
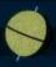
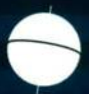
1
31
30
29
28
27

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

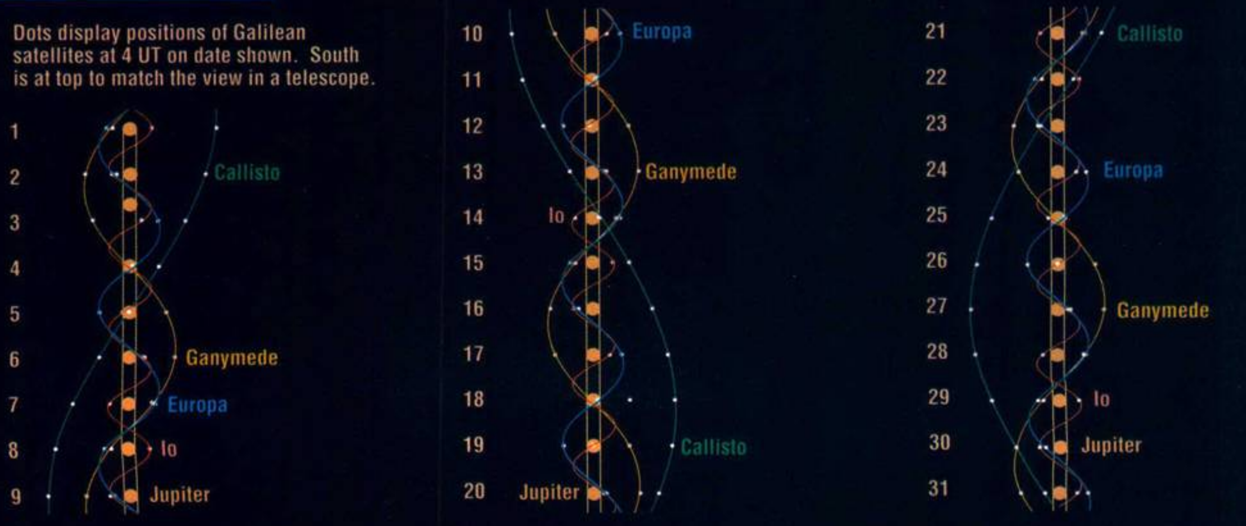


PLANETS	MERCURY	VENUS	MARS
Date	January 31	January 15	January 15
Magnitude	−0.9	−3.9	1.2
Angular Size	6.2"	9.8"	3.9"
Illumination	72%	100%	100%
Distance (AU) from Earth	1.086	1.711	2.402
Distance (AU) from Sun	0.324	0.728	1.424
Right Ascension (2000.0)	22h01.9m	19h45.0m	19h26.6m
Declination (2000.0)	−12°43'	−22°08'	−22°53'

JUPITER'S MOONS

Dots display positions of Galilean satellites at 4 UT on date shown. South is at top to match the view in a telescope.



1994
SKY CALENDAR

From the editors of ASTRONOMY magazine

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photo by Dewey Vanderhoff

JANUARY

S	M	T	W	T	F	S
						1
2	3	4 ◑	5	6	7	8
9	10	11 ●	12	13	14	15
16	17	18	19 ◐	20	21	22
23 30	24 31	25	26	27 ○	28	29

Day	Hour (UT)	
1	**—**	**!! Comet Encke at its best until mid-January** (see 1/94 ASTRONOMY, p. 83, for more information)
2	6	Earth closest to the Sun (perihelion)
4	1	Quadrantid meteors (Last Quarter Moon)
6	**22**	**Jupiter 3° N. of Last Quarter Moon (morning)**
11	8	Neptune in conjunction with Sun (behind Sun)
12	**—**	**Look for young Moon in west at sunset**
	17	Uranus in conjunction with Sun (behind Sun)
15	0	Saturn 7° S. of crescent Moon (evening of 14th for North America)
17	2	Venus in superior conjunction (behind Sun)

Events in **bold** are good astrophotography targets.
Events marked !! are celestial highlights not to be missed.

WHAT'S UT?

When giving times for a celestial event that will be visible over a large geographic area, astronomers use Coordinated Universal Time, abbreviated UTC or just UT. This is the standard time at Greenwich, England, given in the 24-hour style (4 p.m. = 16:00). To find out the time in your time zone subtract the appropriate number of hours:

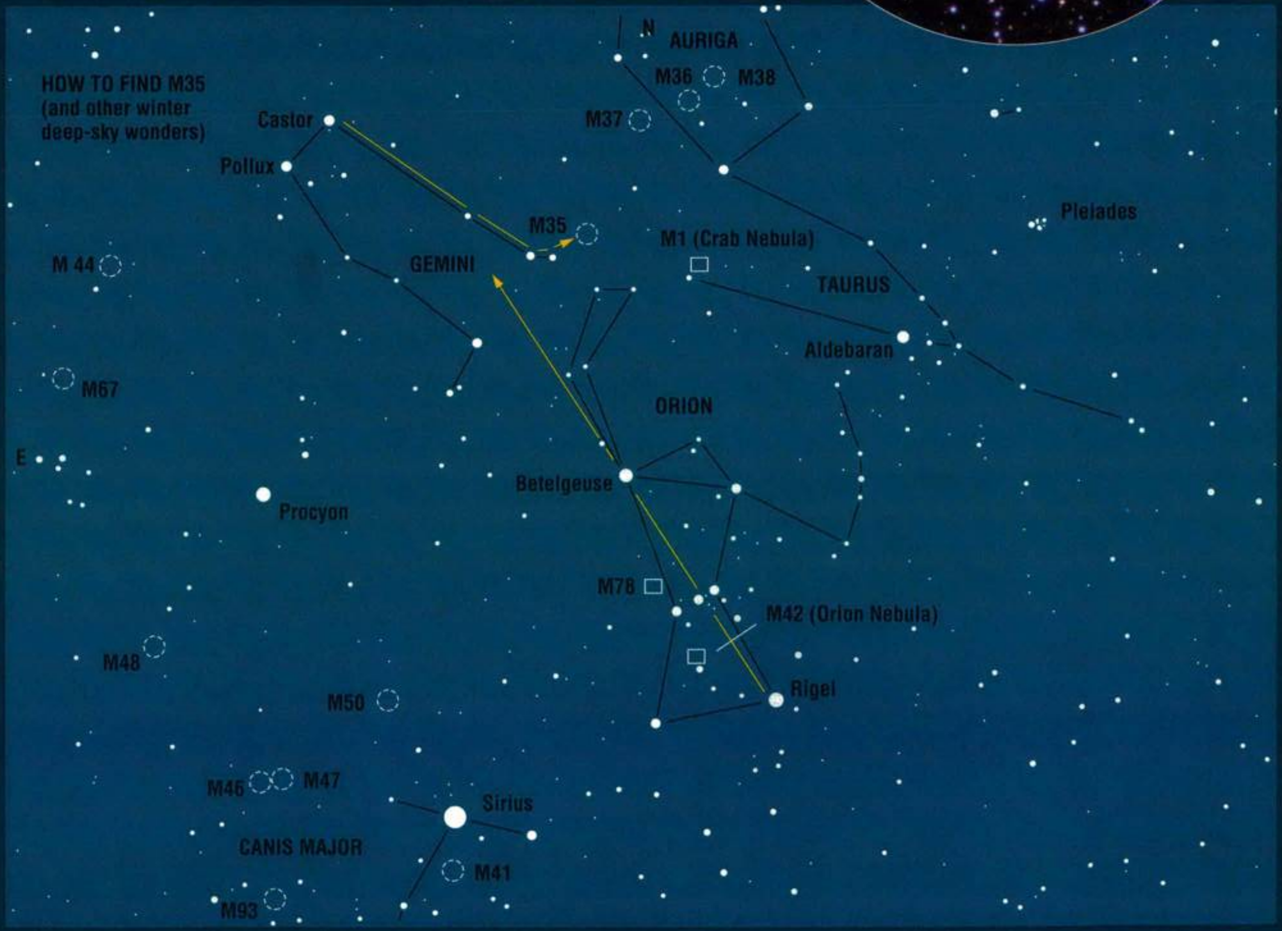
North American Time Zone	Standard Time	Daylight Saving
Atlantic	–4	–3
Eastern	–5	–4
Central	–6	–5
Mountain	–7	–6
Pacific	–8	–7
Alaska	–9	–8
Hawaii	–10	—

TREK ACROSS THE WINTER SKY

If you just got a new telescope for Christmas, you can use the chart below to find two of the best deep-sky wonders, the ghostly green Orion Nebula (also known as M42) and the glittering star cluster called M35 in Gemini. Start your star hop to M42 from the easy-to-find trio of belt stars and surrounding bright stars of Orion the Hunter. These stand due south at about 9:30 p.m. on January evenings. To find the nebula, aim your telescope about a finder-scope field (4°) below the leftmost star of Orion's belt.

To find M35 (shown at right), draw a line from Rigel through the belt stars up to Betelgeuse in Orion's shoulder. Extend that line farther and you come to Gemini the Twins. Just north of Gemini's feet sits M35, one of the sky's best open star clusters.

Sheldon Faworski


HOW TO FIND M35
(and other winter
deep-sky wonders)
N
E
AURIGA
M36
M38
M37
Castor
Pollux
M35
GEMINI
M1 (Crab Nebula)
TAURUS
Pleiades
Aldebaran
M 44
M67
ORION
Betelgeuse
Procyon
M78
M42 (Orion Nebula)
Rigel
M48
M50
M46
M47
Sirius
CANIS MAJOR
M41
M93

FEBRUARY

S	M	T	W	T	F	S
		1	2	3 ◑	4	5
6	7	8	9	10 ●	11	12
13	14	15	16	17	18 ◐	19
20	21	22	23	24	25	26 ○
27	28					

Day	Hour (UT)	
2	**4**	**!! Mercury 1.3° N. of Saturn (evening)**
3	**8**	**Jupiter 3° N. of Last Quarter Moon (morning)**
4	**21**	**Mercury at greatest elong. E. (18°, best evening appearance for northern latitudes)**
8	8	Neptune 3° S. of waning crescent Moon (morning)
	12	Uranus 5° S. of waning crescent Moon (morning)
9	11	Comet Encke at perihelion (closest to Sun)
11	**—**	**Look for young Moon in west at sunset**
	23	Mercury 2° S. of waxing crescent Moon (evening)
21	17	Saturn in conjunction with Sun (behind Sun)
27	**1**	**Mercury 4° N. of Mars (morning)**
28	21	Jupiter stationary

Events in **bold** are good astrophotography targets.
Events marked **!!** are celestial highlights not to be missed.

NOTE: Dark-sky observing windows are indicated by the blue shading on the calendars for each month. At First Quarter Moon, the sky is dark during the last half of the night after moonset. At Last Quarter, the sky is dark during the first half of the night before moonrise.

PLANET CONJUNCTIONS IN 1994

Feb. 2	Mercury 1.3° N. of Saturn
Feb. 27	Mercury 4° N. of Mars
Mar. 14	Mars 0.4° N. of Saturn
Mar. 24	Mercury 0.3° S. of Saturn
Apr. 4	Mercury 1.5° S. of Mars
Nov. 12	Mercury 5° N. of Venus

SPOT ELUSIVE MERCURY

If you've never seen the planet Mercury, this February is a good month to catch it in the evening sky. Mercury is always a tough find because it never strays far from the Sun's glare even at times of maximum elongation. Around these dates, Mercury is as far from the Sun as it gets. During twilight, it's still low in the sky, no more than 10° high for Northern Hemisphere observers.

In the table at right you can see that Mercury is farther from the Sun during the May (23°) and September (26°) evening elongations. Yet the February elongation (18°) is the best. In late winter and spring, the path of the planets across the sky, called the ecliptic, is angled almost straight up from the western horizon, at least as seen from the Northern Hemisphere. This places Mercury much higher in the sky than at elongations later in the year. Look for a magnitude 0.5 "star" shining amid the glow of twilight.

In late January, Saturn joins Mercury (the two are closest on February 2) while on February 11 look for Mercury just south of the waxing crescent Moon.

WHEN TO SEE MERCURY IN 1994

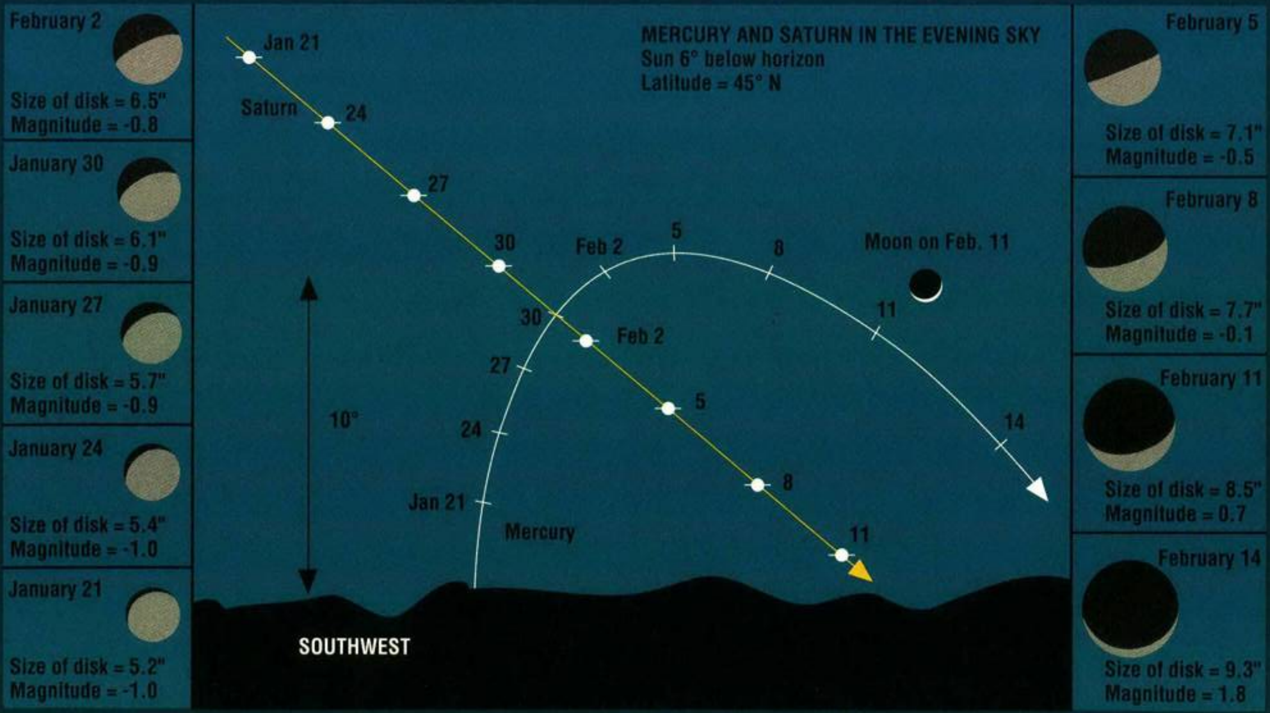
Greatest evening elongations	Visible from	Max. angle from Sun
Feb. 4	Jan. 18 to Feb. 14	18° (best)
May 30	May 8 to June 16	23°
Sept. 26	Aug. 23 to Oct. 15	26°

Greatest morning elongations	Visible from	Max. angle from Sun
Mar. 19	Feb. 27 to Apr. 22	28°
July 17	July 4 to Aug. 5	21°
Nov. 6	Oct. 28 to Nov. 27	19° (best)

WHEN TO SEE VENUS IN 1994

Greatest evening elongation	Visible from	Max. angle from Sun
Aug. 24	Feb. to end of Oct.	46°

Greatest morning elongation	Visible from	Max. angle from Sun
Jan. 13, 1995	Nov. 94 to July 95	47° (in 1995)


MERCURY AND SATURN IN THE EVENING SKY
Sun 6° below horizon
Latitude = 45° N
Jan 21
Saturn
24
27
30
Feb 2
5
8
11
Mercury
Jan 21
24
27
30
Feb 2
5
8
11
14
Moon on Feb. 11
10°
SOUTHWEST
February 2
Size of disk = 6.5"
Magnitude = -0.8
January 30
Size of disk = 6.1"
Magnitude = -0.9
January 27
Size of disk = 5.7"
Magnitude = -0.9
January 24
Size of disk = 5.4"
Magnitude = -1.0
January 21
Size of disk = 5.2"
Magnitude = -1.0
February 5
Size of disk = 7.1"
Magnitude = -0.5
February 8
Size of disk = 7.7"
Magnitude = -0.1
February 11
Size of disk = 8.5"
Magnitude = 0.7
February 14
Size of disk = 9.3"
Magnitude = 1.8

MARCH

S	M	T	W	T	F	S
		1	2	3	4 ◑	5
6	7	8	9	10	11	12 ●
13	14	15	16	17	18	19
20 ◐	21	22	23	24	25	26
27 ○	28	29	30	31		

Day	Hour (UT)	
2	16	Jupiter 2° N. of waning gibbous Moon (morning)
4	1	Pluto stationary
7	16	Neptune 4° S. of crescent Moon (morning)
	21	Uranus 5° S. of waning crescent Moon (morning)
10	**4**	**!! Mercury 5° S. of crescent Moon (morning)**
	23	**!! Mars 7° S. of crescent Moon (morning)**
	—	**!! Mercury, Mars, and Saturn close together (within 10°) for the rest of the month in the dawn sky.**
11	**4**	**Saturn 7° S. of crescent Moon (morning)**
12	**—**	**!! Look for very young Moon in west at sunset**
13	**17**	**!! Venus 5° S. of crescent Moon (evening)**
14	**10**	**!! Mars 0.4° N. of Saturn (morning)**
17	**22**	**Waxing crescent Moon 5° S. of Pleiades cluster**
19	2	Mercury at greatest elong. W. (28°, poor morning appearance for northern latitudes)
20	20	Equinox (northern spring/southern fall begins)
24	**8**	**Mercury 0.3° S. of Saturn (morning)**
27	**11**	**Closest Full Moon of 1994**
29	23	Jupiter 2° N. of waning gibbous Moon (morning)

Events in **bold** are good astrophotography targets.
Events marked **!!** are celestial highlights not to be missed.

DATES FOR THIN CRESCENT MOON

Jan. 11	Age = 22.5 hours
Feb. 10	Age = 32 hours
Mar. 12	Age = 16 hours
Apr. 11	Age = 23 hours
May 11	Age = 29 hours

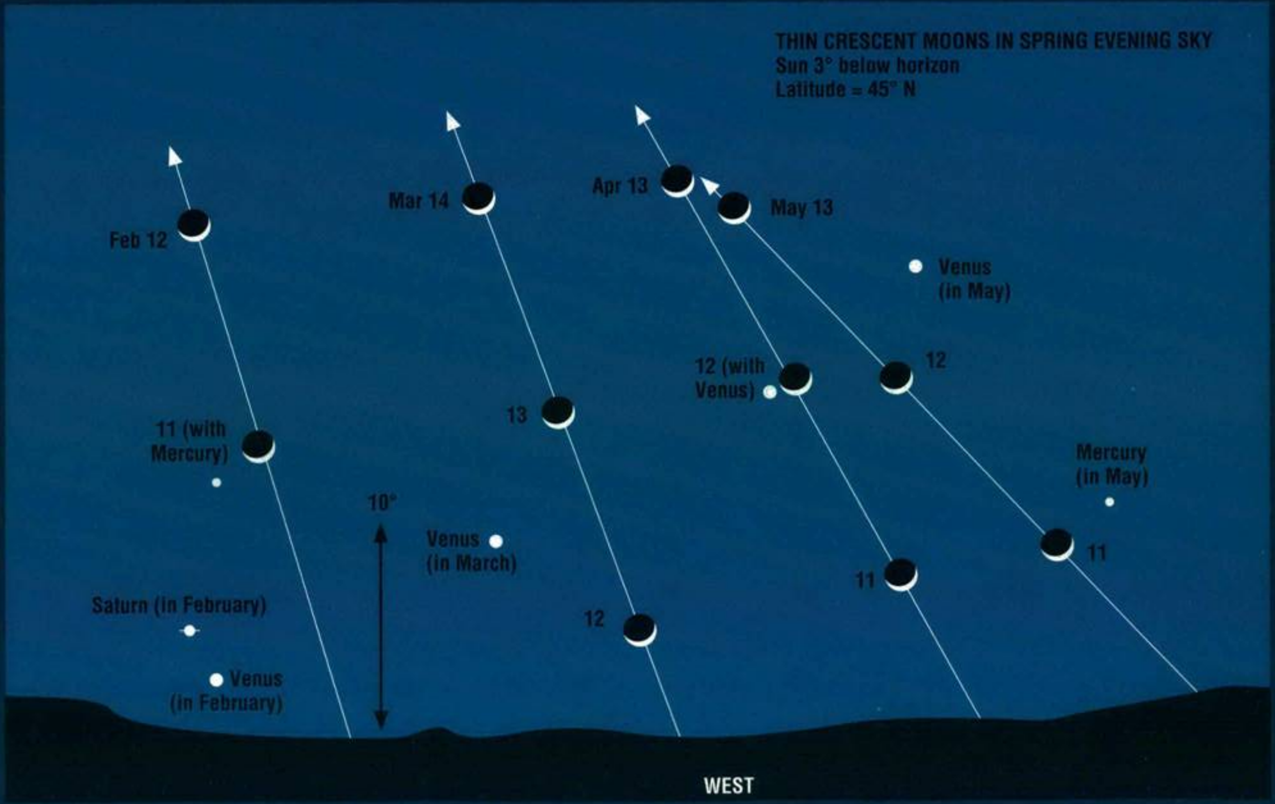
The age is for Boston at sunset. From locations farther west in North America, the Moon will have "aged" some more by the time the Sun sets.

SEE THE YOUNGEST MOON

Brian Tkachyk

A popular observing challenge is sighting the youngest sliver of the crescent Moon in the evening sky. Spring is the best season for hunting the thin crescent Moon because the high angle of the ecliptic (the path of the Moon and planets across the sky) puts the waxing Moon higher in the sky than at other times of the year. From North America, March 12 is the evening to catch the youngest Moon of the year. The exact age of the Moon will vary depending on when you look and where you look from. From the east coast of North America, the Moon will be only 16 hours old on the evening of March 12.

On April 12, the two-day-old Moon will pass in front of Venus, but only as seen from Greenland and the Arctic. The rest of the world will see a striking meeting of the two brightest objects in the night sky, with the two-day-old Moon and Venus only a degree apart, their closest conjunction for the year.



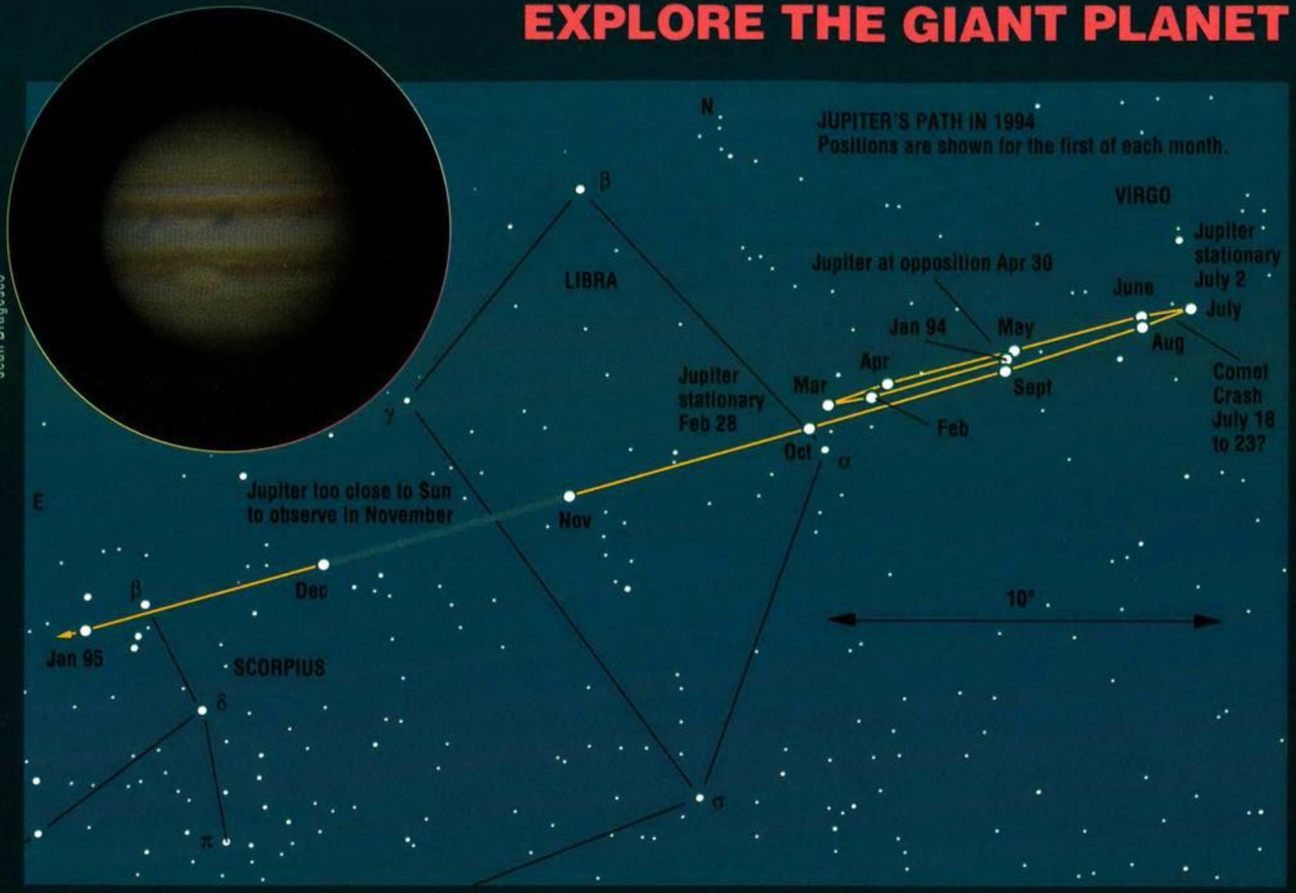
APRIL

S	M	T	W	T	F	S
					1	2
3 ◑	4	5	6	7	8	9
10	11 ●	12	13	14	15	16
17	18	19 ◐	20	21	22	23
24	25 ○	26	27	28	29	30

Day	Hour (UT)	
3	22	Neptune 4° S. of Last Quarter Moon (morning)
	—	Daylight Saving Time begins
4	**2**	**Mercury 1.5° S. of Mars (morning)**
	4	Uranus 5° S. of Last Quarter Moon (morning)
7	16	Saturn 7° S. of waning crescent Moon (morning)
9	**2**	**Mars 6° S. of waning crescent Moon (morning)**
	11	**Mercury 7° S. of crescent Moon (morning)**
11	**—**	**Look for young Moon in west at sunset**
12	**23**	**!! Venus 1° S. of crescent Moon (evening) (occultation visible from Greenland and the Arctic)**
14	**7**	**Waxing crescent Moon 5° S. of Pleiades cluster** (evening of 13th for North America)
15	1	Asteroid 3 Juno at opposition
16	—	!! International Astronomy Day
22	9	Lyrid meteors (waxing gibbous Moon)
24	**—**	**Venus 4° S. of Pleiades cluster (M45)**
25	9	Neptune stationary
26	5	Jupiter 3° N. of nearly Full Moon
30	**9**	**!! Jupiter at opposition (rises at sunset)**

Events in **bold** are good astrophotography targets.
Events marked **!!** are celestial highlights not to be missed.

EXPLORE THE GIANT PLANET


JUPITER'S PATH IN 1994
Positions are shown for the first of each month.
N
E
VIRGO
LIBRA
SCORPIUS
Jupiter stationary July 2
July
June
Aug
Comet Crash July 18 to 23?
Jupiter at opposition Apr 30
Jan 94
May
Sept
Apr
Feb
Mar
Jupiter stationary Feb 28
Oct
α
β
γ
σ
δ
π
Nov
Jupiter too close to Sun to observe in November
Dec
Jan 95
10°

Jean Dragesco

April is prime time for Jupiter. On April 30 the Sun, Earth, and Jupiter lie in a straight line, an alignment called "opposition." From our vantage point, Jupiter appears directly opposite the Sun in our sky. As the Sun sets, Jupiter rises, putting it in the sky all night. Jupiter lies due south at midnight and sets as the Sun comes up. Before opposition on April 30 Jupiter rises after sunset. After April 30, Jupiter rises before the Sun goes down and is well up in the east as it gets dark.

At opposition, Jupiter is closest to Earth and through a telescope its disk looks as large as it gets for the year, about 44.5" across. At 100x to 150x, you'll see at least two dark cloud belts near the equator of the planet (provided Jupiter's weather is behaving normally). Thinner belts lie north and south of the equatorial region, while the Red Spot may be visible as a gray oval on the edge of the South Equatorial Belt.

During 1994 Jupiter moves from Virgo, through Libra, and into western Scorpius. It will then spend the next few years traversing the southern constellations of Scorpius, Sagittarius, and Capricornus. For northern observers, this will place Jupiter low in the sky where atmospheric turbulence can blur the view. For these observers, at least, this is the best year for watching Jupiter until 1998.

MAY

S	M	T	W	T	F	S
1	2 ◐	3	4	5	6	7
8	9	10 ●	11	12	13	14
15	16	17	18 ◑	19	20	21
22	23	24	25 ○	26	27	28
29	30	31				

Day	Hour (UT)	
1	1	Uranus stationary
	6	Neptune 4° S. of Last Quarter Moon (morning)
	12	Uranus 5° S. of Last Quarter Moon (morning)
5	0	Venus 6° N. of Aldebaran (evening of 4th for North America)
	3	Saturn 7° S. of waning crescent Moon (morning)
	8	Eta Aquarid meteors (waning crescent Moon)
8	4	Mars 4° S. of waning crescent Moon (morning)
10	**17**	**!! Annular eclipse of the Sun (North America)**
11	**—**	**Look for young Moon in west at sunset**
13	**6**	**!! Venus 4° N. of waxing crescent Moon** (evening of 12th for North America)
15	11	Mercury 8° N. of Aldebaran (evening)
17	**20**	**Pluto at opposition (rises at sunset)**
23	11	Jupiter 3° N. of waxing gibbous Moon (evening)
25	**3**	**!! Partial eclipse of Moon (see June for details)**
28	14	Neptune 4° S. of gibbous Moon (morning)
	20	Uranus 5° S. of waning gibbous Moon (morning)
30	**7**	**Mercury at greatest elong. E. (23°, good evening appearance for northern latitudes)**

Events in **bold** are good astrophotography targets.
Events marked **!!** are celestial highlights not to be missed.

MAY 10: VIEW THE ECLIPSE SAFELY

We recommend only two filters for viewing the Sun: an ultraviolet-coated #14 gas welder's filter (check welding supply shops) and the aluminized Mylar filters sold by astronomy dealers.

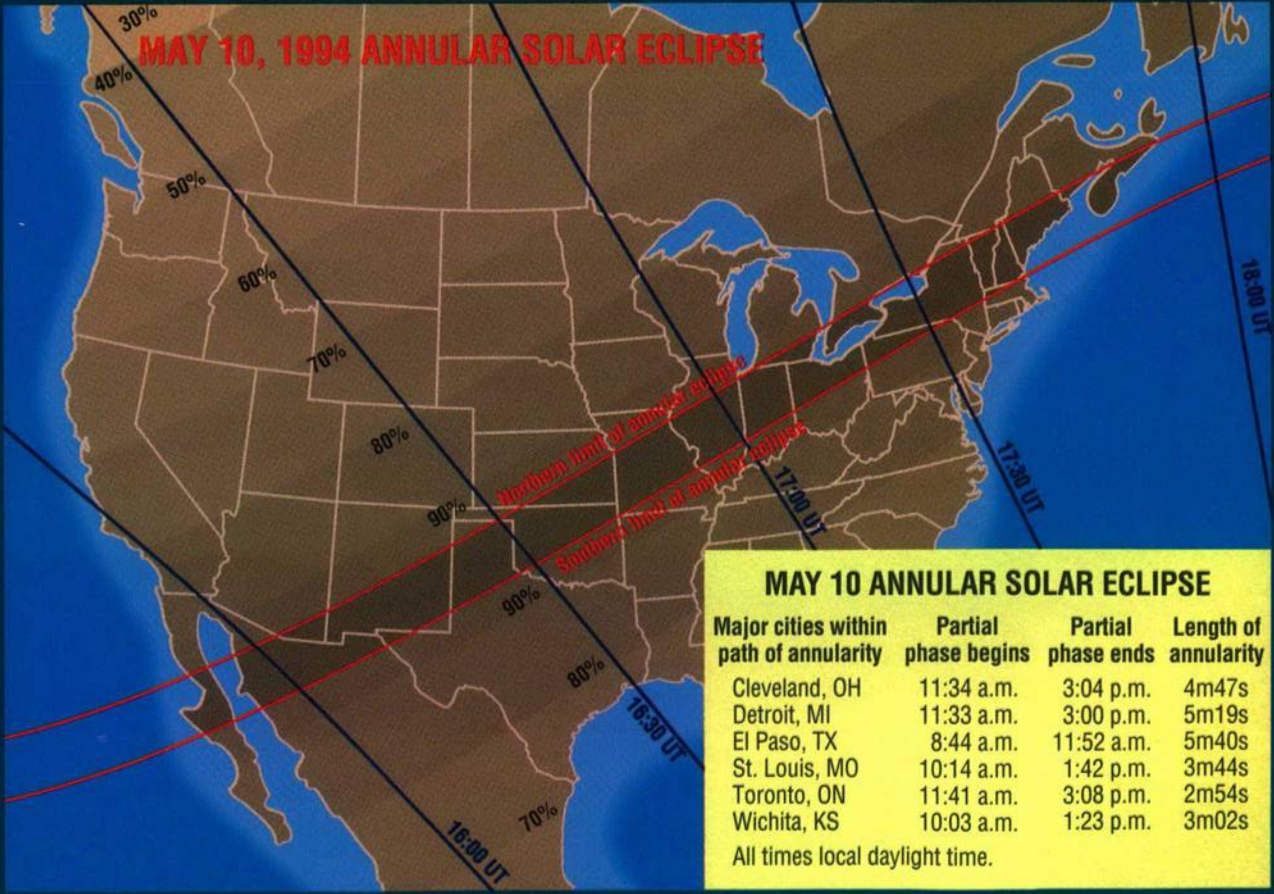
You can also view the Sun safely by projection. Remove the lid from a box, punch a pinhole in one end, and glue white paper to the inside of the opposite end. Hold the box upside down over your head and face the white paper. Point the pinhole toward the Sun. You'll see a small image of the Sun projected onto the paper.

WATCH A RARE ANNULAR ECLIPSE

The astronomical highlight of the year for North American skywatchers comes at midday on May 10 when the Moon's shadow races across the continent. Everyone within the central path will have a chance to see an annular eclipse of the Sun. The Moon will pass directly in front of the Sun's disk but will not be large enough to block out the disk entirely. Instead of seeing a total eclipse, we'll see the Sun as a thin ring of light. This ring, or annulus, is extremely bright and must be viewed only through proper filters.

Many major cities lie within the path of annularity. Those near the center line will see the Moon contained entirely within the Sun's disk for up to six minutes and 13 seconds of annularity. Toledo, Ohio, lies near the point of maximum eclipse. Outside the path of annularity, the rest of North America will witness a partial eclipse of the Sun. More details about this major event, including specific eclipse times for North American locations, will appear in upcoming issues of ASTRONOMY.

Dewey Vanderhoff


MAY 10, 1994 ANNULAR SOLAR ECLIPSE
30%
40%
50%
60%
70%
80%
90%
90%
80%
70%
Northern limit of annular eclipse
Southern limit of annular eclipse
16:00 UT
16:30 UT
17:00 UT
17:30 UT
18:00 UT

MAY 10 ANNULAR SOLAR ECLIPSE

Major cities within path of annularity	Partial phase begins	Partial phase ends	Length of annularity
Cleveland, OH	11:34 a.m.	3:04 p.m.	4m47s
Detroit, MI	11:33 a.m.	3:00 p.m.	5m19s
El Paso, TX	8:44 a.m.	11:52 a.m.	5m40s
St. Louis, MO	10:14 a.m.	1:42 p.m.	3m44s
Toronto, ON	11:41 a.m.	3:08 p.m.	2m54s
Wichita, KS	10:03 a.m.	1:23 p.m.	3m02s

All times local daylight time.

JUNE

S	M	T	W	T	F	S
			1 ◑	2	3	4
5	6	7	8	9 ●	10	11
12	13	14	15	16 ◐	17	18
19	20	21	22	23 ○	24	25
26	27	28	29	30 ◑		

Day	Hour (UT)	
1	**—**	**Comet Tempel 1 at maximum brightness** (at about mag. 9 throughout June)
	12	Saturn 7° S. of Last Quarter Moon (morning)
6	**5**	**Mars 2° S. of waning crescent Moon (morning)**
10	5	Venus 5° S. of Pollux (evening of 9th for North America)
11	0	Mercury 3° N. of waxing crescent Moon (evening of 10th for North America)
12	**13**	**Venus 7° N. of waxing crescent Moon (evening)**
19	16	Jupiter 3° N. of waxing gibbous Moon (evening)
20	**—**	**Venus 0.5° N. of Beehive cluster (M44)**
21	15	Solstice (northern summer/southern winter begins)
24	4	Saturn stationary
	23	Neptune 4° S. of nearly Full Moon
25	5	Uranus 5° S. of nearly Full Moon
28	21	Saturn 7° S. of waning gibbous Moon (morning)

MAY 24/25 PARTIAL LUNAR ECLIPSE

Two weeks after the annular eclipse, the Moon will pass through Earth's shadow. Viewers in eastern and central North America will see a partial eclipse of the Moon with about 25 percent of the Moon's disk darkened by the umbral shadow at mid-eclipse. Those in western North America will see the Moon rise already in eclipse.

	UT	EDT
Event	**May 25**	**May 24**
Moon enters penumbra	1h 18m	9:18 p.m.
Moon enters umbra	2h 37m	10:37 p.m.
Middle of eclipse	3h 30m	11:30 p.m.
Moon leaves umbra	4h 23m	12:23 a.m. *(May 25)*
Moon leaves penumbra	5h 43m	1:43 a.m. *(May 25)*

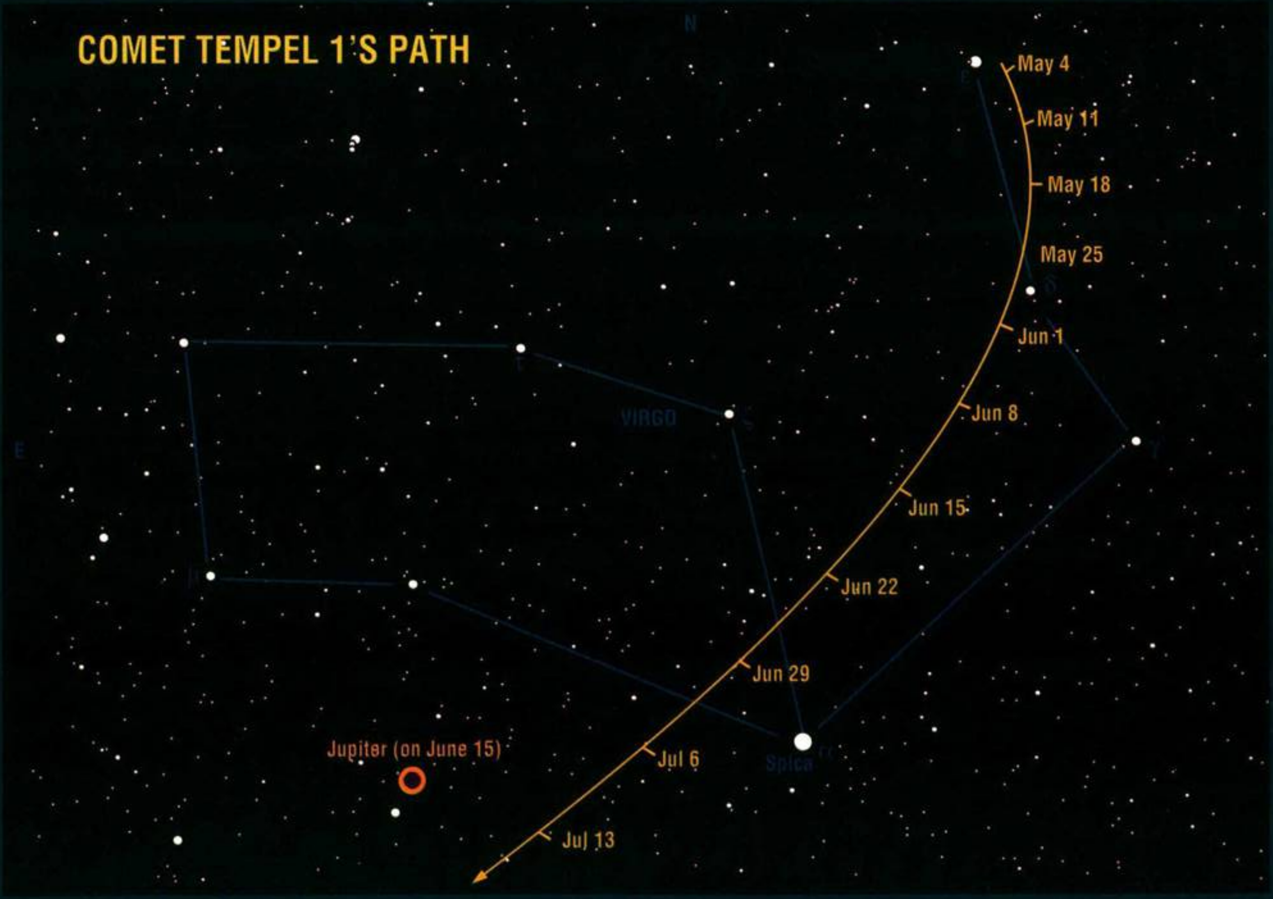
FOLLOW A BINOCULAR COMET

This is a good year for comets. While no really bright comets are predicted to make a return in 1994, several comets will become bright enough to be visible in binoculars or a small telescope. Comet Encke put in an appearance in January (see the January 1994 ASTRONOMY). This month, Comet Tempel 1 is at its brightest, glowing at 9th magnitude for much of June (provided the comet behaves as predicted).

The best time to look for Comet Tempel 1 is early June. The Moon will be out of the sky so its light will not interfere with the view. Look for the comet as a small, amorphous patch of light, like a fuzzy star, amid the stars of Virgo northwest of the bright star Spica and the planet Jupiter. From a dark site, binoculars such as 7x50 or 10x50 models should be sufficient for finding the comet. Big binoculars such as 11x80s are ideal. A telescope may reveal a starlike nucleus and perhaps a hint of a tail.

COMET TEMPEL 1 COORDINATES

Date		RA (2000)	Dec.	Mag.
May	8	12h 59m	09° 45'	9.3
May	18	12h 57m	07° 11'	9.1
May	28	12h 59m	04° 00'	8.9
June	7	13h 05m	00° 23'	8.9
June	17	13h 15m	–03° 30'	8.9
June	27	13h 30m	–07° 32'	8.9
July	7	13h 48m	–11° 33'	9.1
July	17	14h 08m	–15° 27'	9.2
July	27	14h 31m	–19° 06'	9.5



COMET TEMPEL 1'S PATH

JULY

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8 ●	9
10	11	12	13	14	15	16 ◑
17	18	19	20	21	22 ○	23
24 31	25	26	27	28	29	30 ◐

Day	Hour (UT)	
2	16	Jupiter stationary
3	7	Comet Tempel 1 at perihelion (closest to Sun)
5	—	**Mars between Pleiades & Hyades for next week**
	2	**!! Crescent Moon 5° S. of Pleiades cluster (M45)**
	5	**!! Mars 0.3° N. of crescent Moon (morning) (occultation visible from S.E. Asia)**
	19	Earth farthest from the Sun (aphelion)
7	13	Mercury 1.3° S. of crescent Moon (morning)
10	**17**	**Venus 1.1° N. of Regulus (evening)**
12	**12**	**Venus 7° N. of waxing crescent Moon (evening)**
14	16	Neptune at opposition (rises at sunset)
16	23	Jupiter 3° N. of First Quarter Moon (evening)
17	4	Uranus at opposition (rises at sunset)
	14	**Mercury at greatest elong. W. (21°, good morning appearance for northern latitudes)**
18	—	**!! First pieces of Comet Shoemaker-Levy 9 hit Jupiter?**
	21	Mars 5° N. of Aldebaran (morning)
21	—	**!! Middle pieces of Comet Shoemaker-Levy 9 hit Jupiter?**
22	7	Neptune 4° S. of Full Moon
	12	Uranus 5° S. of Full Moon
23	—	**!! Last pieces of Comet Shoemaker-Levy 9 hit Jupiter?**
26	4	Saturn 7° S. of waning gibbous Moon (morning)
28	23	Delta Aquarid meteors (waning gibbous Moon)
31	7	Mercury 6° S. of Pollux (morning)

Events in **bold** are good astrophotography targets.
Events marked !! are celestial highlights not to be missed.

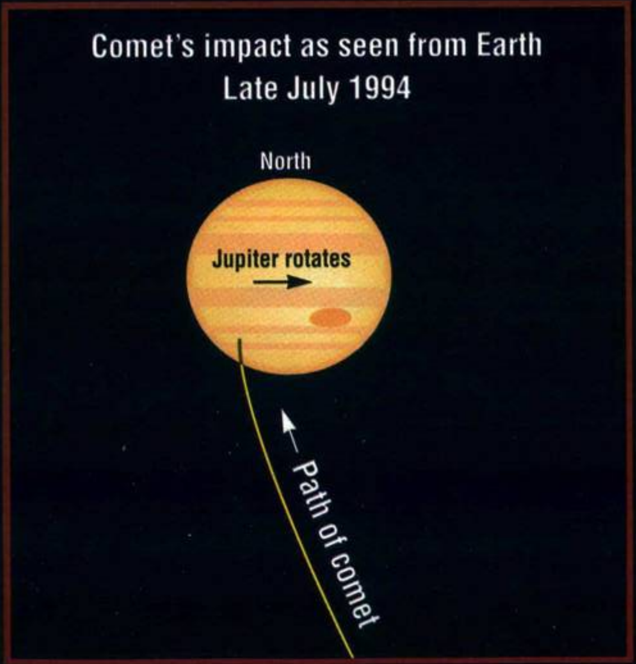
WITNESS THE GREAT COMET CRASH

This is the month for what could be one of the most unusual celestial events ever witnessed. Around July 21, pieces of Comet Shoemaker-Levy 9 now in orbit around Jupiter will collide with the giant planet. Over the course of several days, the comet fragments (there are at least 20) will each come up from below Jupiter and pass behind the planet as seen from Earth. The collisions will occur on the night side of the planet, out of sight of Earthbound eyes.

However, as each piece of icy comet debris plunges through the atmosphere, it will explode, perhaps creating a long-lived disturbance in the cloud belts of Jupiter. About 90 minutes after each collision, the impact site will rotate into view. What form these disturbances will take is hard to predict. But by watching Jupiter intently in the weeks prior to the impacts, you'll come to know Jupiter's "normal" appearance and will be better able to detect any abnormal features on the disk.

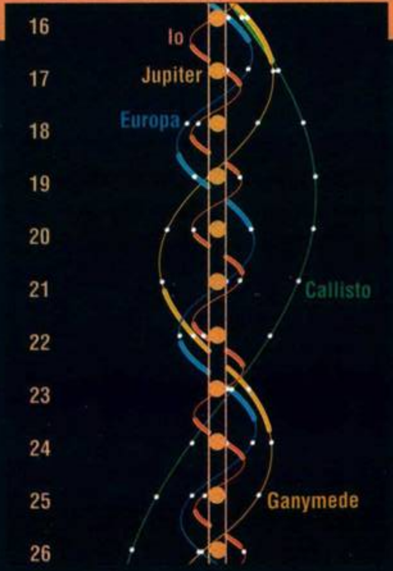
Detailed predictions of the times of the impacts will appear in ASTRONOMY in issues prior to the Great Comet Crash of '94.

James Scotti



FLASHES ON THE MOONS?

It is possible that the flashes from Shoemaker-Levy's impacts may light up the moons of Jupiter, increasing their brightness for a few brief moments (although the increase in magnitude is difficult to estimate). For a moon to be lit up, it must be on the back side of Jupiter. The graph below shows the positions of the four largest Jovian moons during the predicted impact times and highlights periods in bold when each moon is well positioned.



AUGUST

S	M	T	W	T	F	S
	1	2	3	4	5	6
7 ●	8	9	10	11	12	13
14 ◐	15	16	17	18	19	20
21 ○	22	23	24	25	26	27
28	29 ◑	30	31			

Day	Hour (UT)	
1	**7**	**Crescent Moon 5° S. of Pleiades cluster (M45)**
3	4	Mars 3° N. of waning crescent Moon (morning)
9	14	Pluto stationary
10	**23**	**Venus 3° N. of waxing crescent Moon (evening)**
12	**21**	**!! Perseid meteors peak (waxing crescent Moon)**
13	7	Jupiter 2° N. of First Quarter Moon (evening of 12th for North America)
18	14	Neptune 4° S. of waxing gibbous Moon (evening)
	18	Uranus 5° S. of waxing gibbous Moon (evening)
19	**—**	**!! Mars 0.7° S. of M35 cluster**
22	10	Saturn 7° S. of nearly Full Moon
24	23	Venus at greatest elong. E. (46°, poor evening appearance for northern latitudes)
31	4	Asteroid 4 Vesta 0.7° S. of waning crescent Moon
	21	Venus 0.7° S. of Spica (evening)

Events in **bold** are good astrophotography targets.
Events marked !! are celestial highlights not to be missed.

WHAT'S A MAGNITUDE?

The brightness of a celestial object is called its magnitude. The magnitude scale works backward from what you might expect: Stars with a large magnitude number, say 9, appear fainter than stars with a magnitude of 1. The faintest stars you can see with the unaided eye at a dark-sky site are magnitude 6 to 7. At the other end of the scale, the brightest stars shine at magnitude 1 or 0. Planets can be brighter still: Jupiter shines at –2.5 in April and May while Venus reaches –4.7 as a brilliant morning star in early December.

ENJOY A METEOR SHOWER

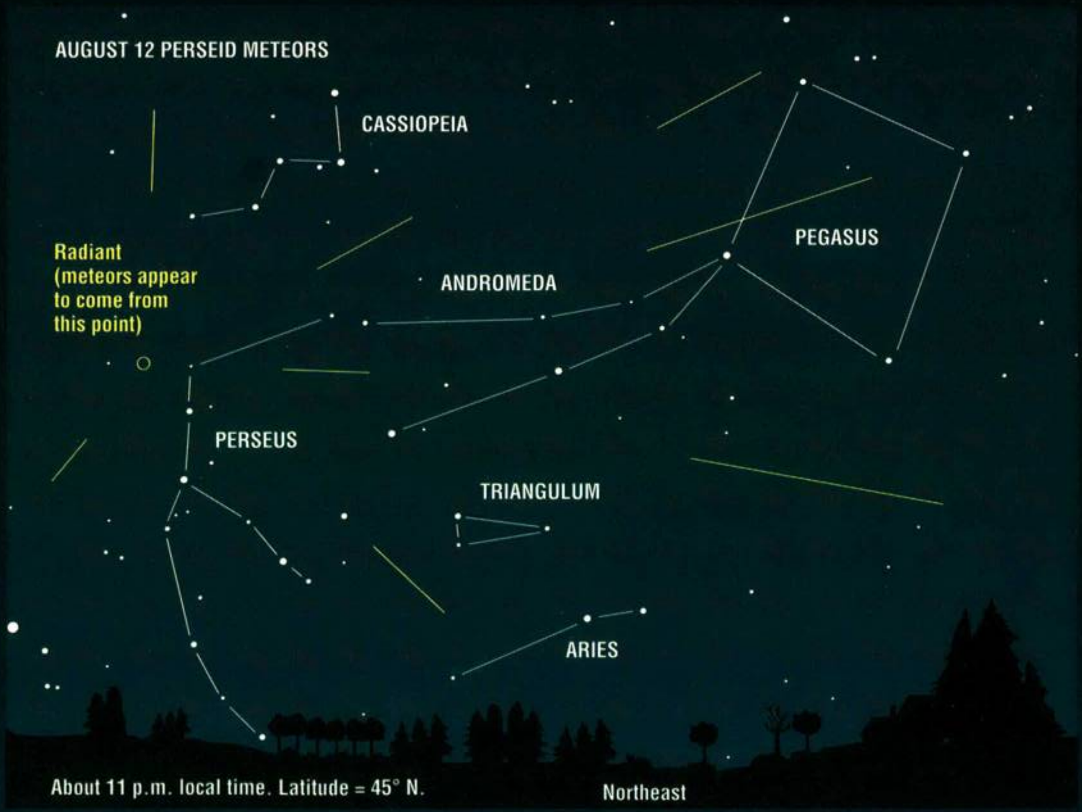
August is meteor month. Each year the annual Perseid meteors put on a summertime show. Last year, millions of people around the world ventured into the night to watch the Perseids. The occasion was the possibility of a once-in-a-lifetime meteor storm. Because the parent comet of the Perseids, Comet Swift-Tuttle, had returned to the inner solar system in late 1992, some astronomers suspected Earth might pass through an especially dense stream of meteoroid particles spewed out by the comet. No storm appeared, but meteor watchers around the world reported one of the best Perseid displays in recent memory.

This year, some astronomers are again predicting a chance (just a chance, mind you) of a storm — or at least abnormally heightened activity. For North American observers, the best times to look will be after midnight on the night of August 11/12 and then again on August 12/13. The Moon will be in the sky early in the evening both nights but will set about 10:30 to 11 p.m. local time. Expect to see about 50 to 80 meteors per hour from a dark site.

MAJOR METEOR SHOWERS IN 1994

Shower	Date	Rate (#/hr)	Viewing Conditions
Quadrantids	Jan. 3/4	95	Good
Lyrids	Apr. 21/22	15	Poor
η Aquarids	May 4/5	30	Good
δ Aquarids	July 28	20	Fair
Perseids	Aug. 12	95	Very good
Orionids	Oct. 21/22	20	Fair
S. Taurids	Nov. 3	15	Good
Leonids	Nov. 17	15	Poor
Geminids	Dec. 13/14	90	Poor

Viewing conditions depend on whether the Moon is present and the peak of the shower occurs at night for North America.


AUGUST 12 PERSEID METEORS
CASSIOPEIA
PEGASUS
Radiant (meteors appear to come from this point)
ANDROMEDA
PERSEUS
TRIANGULUM
ARIES
About 11 p.m. local time. Latitude = 45° N.
Northeast

SEPTEMBER

S	M	T	W	T	F	S
				1	2	3
4	5 ●	6	7	8	9	10
11	12 ◑	13	14	15	16	17
18	19 ○	20	21	22	23	24
25	26	27	28 ◐	29	30	

Day	Hour (UT)	
1	3	Mars 4° N. of waning crescent Moon (morning)
	17	**!! Saturn at opposition (rises at sunset)**
7	9	Mercury 3° N. of waxing crescent Moon (evening of 6th for North America)
9	**1**	**!! Venus 2° S. of waxing crescent Moon (best seen on evening of 8th for North America)**
	20	**!! Jupiter 1.4° N. of waxing crescent Moon (best seen on evening of 8th for North America)**
14	19	Neptune 4° S. of waxing gibbous Moon (evening)
	23	Uranus 5° S. of waxing gibbous Moon (evening)
18	13	Saturn 7° S. of nearly Full Moon
19	**20**	**!! Full Moon (Harvest Moon)**
21	13	Mercury 0.1° S. of Spica (evening)
23	6	Equinox (northern fall/southern spring begins)
24	15	Mars 6° S. of Pollux (morning)
26	16	Mercury at greatest elong. E. (26°, poor evening appearance for northern latitudes)
28	3	Asteroid 4 Vesta 0.06° N. of Last Quarter Moon
	22	**!! Venus at greatest brilliancy (mag. –4.6, evening)**
29	20	Jupiter 0.5° N. of mag. 2.7 star Alpha^2 Librae (evening)
	22	Mars 6° N. of Last Quarter Moon (morning)

Events in **bold** are good astrophotography targets.
Events marked !! are celestial highlights not to be missed.

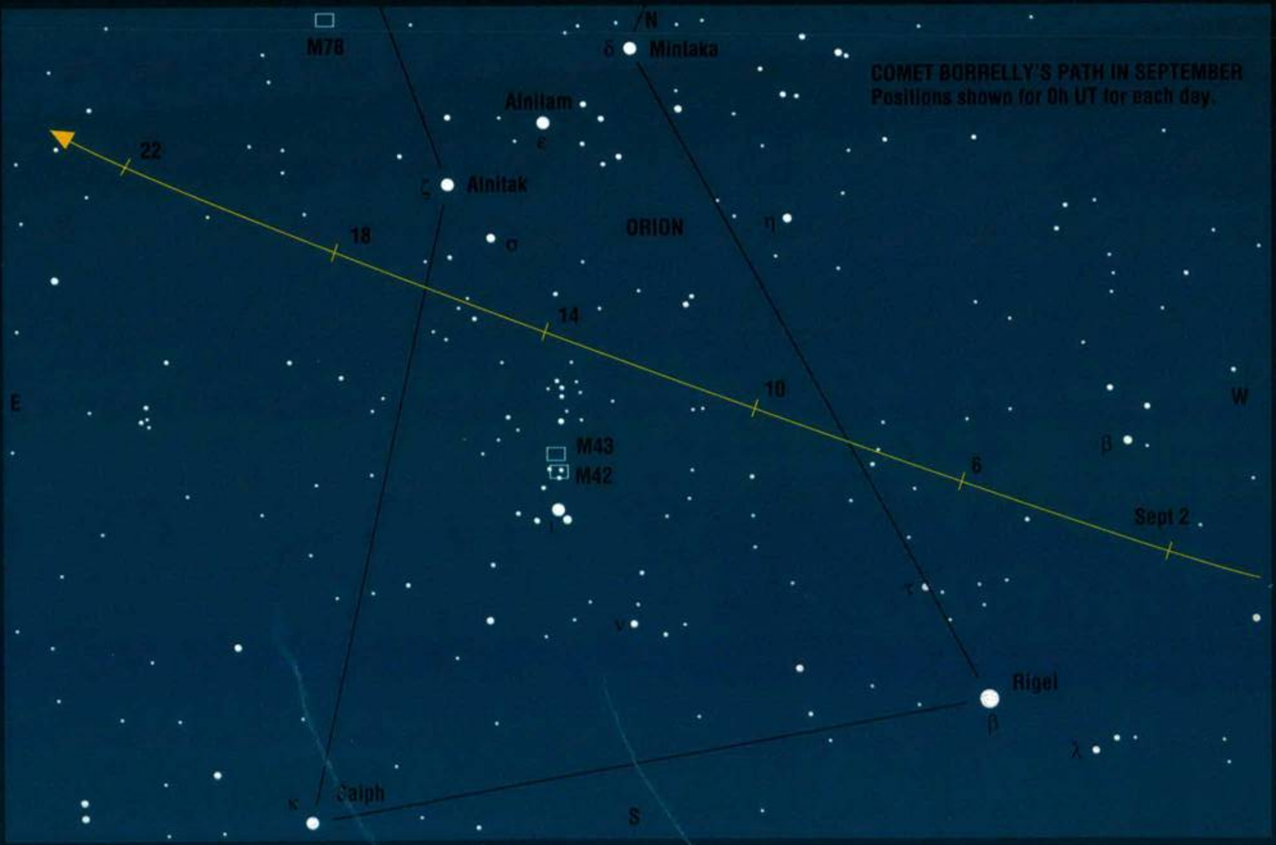
TRACK A COMET THROUGH ORION

The year's third good comet (after Encke in January and Tempel 1 in June) begins a year-end show this month. Comet Borrelly, a comet with a 6.9-year orbit around the Sun, brightens to better than 10th magnitude this month (if it behaves as expected). Borrelly reaches maximum brightness in mid-November shortly after reaching perihelion, its closest point to the Sun. At that time, the comet will appear as a magnitude 7.0 object in Cancer. (Detailed maps of the path of Borrelly for the rest of the year will appear in late-1994 issues of ASTRONOMY.)

This month, however, you can begin following Borrelly as it crosses one of the best-known areas of the sky, the sword of Orion. In mid-September, with the Moon out of the morning sky, Comet Borrelly passes only 2° north of the Orion Nebula. Look for a 9th-magnitude fuzzy star moving slowly from night to night. Binoculars should be sufficient for picking out the comet.

COMET BORRELLY COORDINATES

Date	RA (2000)	Dec.	Mag.
Sept. 5	5h13m	–05°42'	9.4
Sept. 15	5h38m	–03°29'	8.9
Sept. 25	6h04m	–00°52'	8.4
Oct. 5	6h30m	02 17'	8.0
Oct. 15	6h56m	06°07'	7.6
Oct. 25	7h22m	10°49'	7.3
Nov. 4	7h48m	16°31'	7.1
Nov. 14	8h14m	23°17'	7.0
Nov. 24	8h39m	30°56'	7.1
Dec. 4	9h03m	39°05'	7.2
Dec. 14	9h24m	47°06'	7.5
Dec. 24	9h41m	54°20'	7.9


COMET BORRELLY'S PATH IN SEPTEMBER
Positions shown for 0h UT for each day.

OCTOBER

S	M	T	W	T	F	S
						1
2	3	4	5 ●	6	7	8
9	10	11 ◐	12	13	14	15
16	17	18	19 ○	20	21	22
23 30	24 31	25	26	27 ◑	28	29

Day	Hour (UT)	
2	3	Uranus stationary
	14	Neptune stationary
6	18	Mercury 3° S. of waxing crescent Moon (evening)
7	**10**	**!! Venus 7° S. of crescent Moon (evening)**
	12	**!! Jupiter 0.7° N. of crescent Moon (evening)** (occultation of Jupiter visible from S. Atlantic)
12	1	Neptune 4° S. of First Quarter Moon (evening)
	4	Uranus 5° S. of First Quarter Moon (evening)
	23	Venus stationary
15	16	Saturn 7° S. of waxing gibbous Moon (evening)
17	**20**	**!! Mars within Beehive star cluster (M44)**
19	**12**	**!! Full Moon (Hunter's Moon)**
22	2	Orionid meteors (waning gibbous Moon)
25	19	Asteroid 4 Vesta 0.6° N. of gibbous Moon
28	13	Mars 7° N. of Last Quarter Moon (morning)
30	—	Daylight Saving Time ends

Events in **bold** are good astrophotography targets.
Events marked **!!** are celestial highlights not to be missed.

MARS AND THE BEEHIVE

Mars opens its season of viewing with a celestial fanfare. On October 17 it will pass through the center of the Beehive star cluster, M44, one of the sky's brightest and largest clusters. Mars will be within 1° or so of the Beehive for the two days preceding and following the closest approach. This event is ideal for viewing through binoculars.

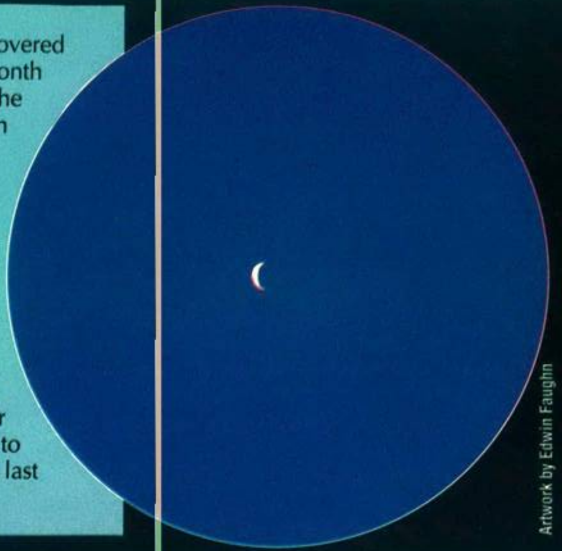
SEE VENUS MAKE ITS SUNWARD PLUNGE

Throughout the summer and early autumn, a bright object has hovered low in the western evening sky. That bright object is Venus. This month Venus ends its apparition as an evening star and descends into the glare of the Sun. As it does so, it undergoes a rapid transition as seen through a telescope.

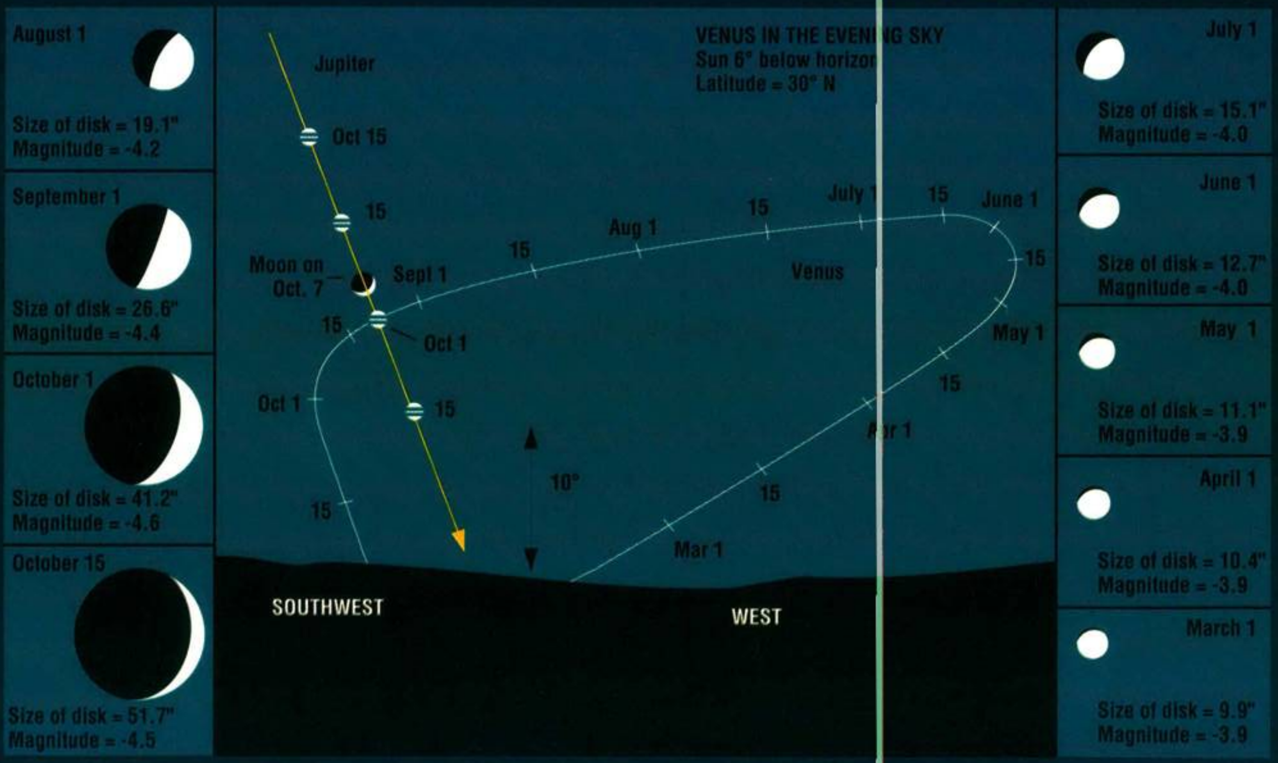
At the beginning of September, Venus looked like a tiny quarter Moon through a telescope. As October opens, Venus' disk has grown in size and its phase has dwindled to a fat crescent. By mid-October, Venus appears as a thin crescent.

Be sure to look on the evening of October 7 when Jupiter will be less than a degree from the waxing crescent Moon, with bright Venus 7° to the south, a picturesque sight in the sunset sky.

Observers at northern latitudes may lose sight of Venus by mid-October, but those farther south (below 30° N.) can follow Venus for a few more days. On November 2, Venus reaches inferior conjunction — it is between Earth and the Sun. Venus then moves to the other side of the Sun and reappears in the morning sky for the last two months of 1994 and the first half of 1995.



Artwork by Edwin Faughn



NOVEMBER

S	M	T	W	T	F	S
		1	2	3 ●	4	5
6	7	8	9	10 ◑	11	12
13	14	15	16	17	18 ○	19
20	21	22	23	24	25	26 ◐
27	28	29	30			

Day	Hour (UT)	
1	12	Comet Borrelly at perihelion (closest to Sun)
2	10	Mercury 4° N. of crescent Moon (morning)
	23	Venus at inferior conjunction (between Earth and Sun)
3	1	Mercury 4° N. of Spica (morning)
	7	S. Taurid meteors (New Moon)
	14	**!! Total eclipse of the Sun (South America)**
6	**1**	**Mercury at greatest elong. W. (19°, best morning appearance for northern latitudes)**
8	8	Neptune 4° S. of waxing crescent Moon (evening)
	12	Uranus 6° S. of waxing crescent Moon (evening)
	20	Asteroid 2 Pallas at opposition
9	21	Saturn stationary
11	21	Saturn 7° S. of First Quarter Moon (evening)
12	**18**	**Mercury 5° N. of Venus (morning)**
14	**—**	**!! Comet Borrelly at max. brightness (mag. 7)**
17	20	Jupiter in conjunction with Sun (behind Sun)
	22	Leonid meteors (Full Moon)
18	**7**	**Penumbral eclipse of the Moon (North and South America)**
	7	**Farthest Full Moon of 1994**
20	13	Pluto in conjunction with Sun (behind Sun)
21	16	Venus stationary
22	0	Asteroid 4 Vesta 1° N. of waning gibbous Moon
25	20	Mars 8° N. of Last Quarter Moon (morning)
30	**14**	**Venus 2° N. of waning crescent Moon (morning)**

Events in **bold** are good astrophotography targets.
Events marked **!!** are celestial highlights not to be missed.

TRAVEL TO A TOTAL ECLIPSE

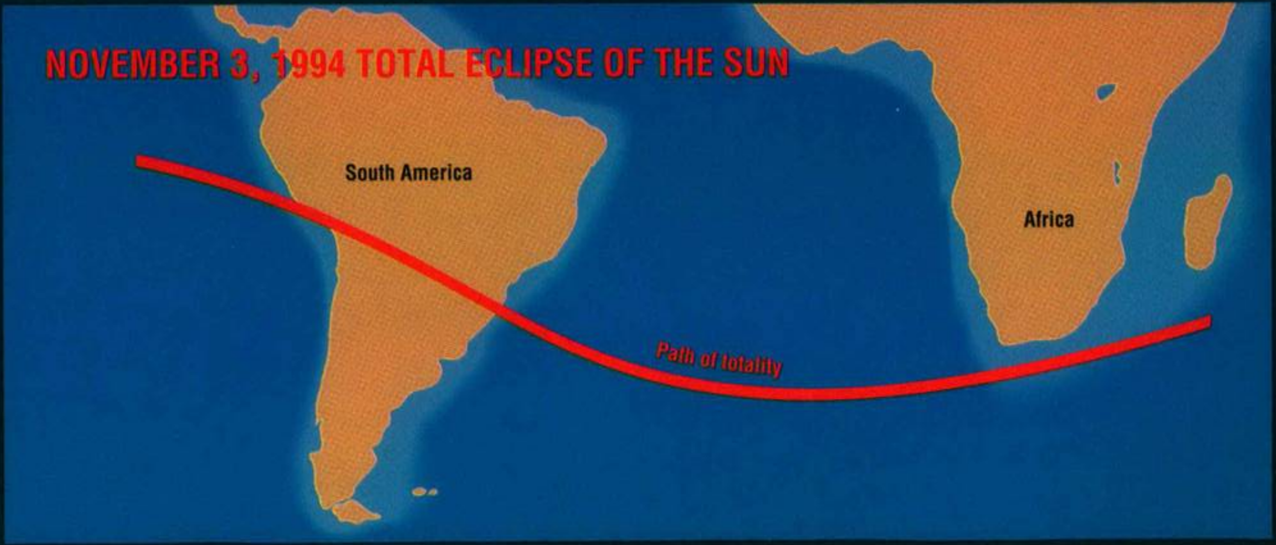
For eclipse chasers, the best event of 1994 occurs on November 3. But to see this celestial spectacle you'll need to travel to South America. The event is a total eclipse of the Sun, visible along a path from southern Peru and northern Chile, across Bolivia and Paraguay, and into southern Brazil. Weather prospects at many sites — especially on the high plains of Bolivia — are very good.

At maximum eclipse, at a point in the South Atlantic, the Moon will cover the Sun for 4 minutes and 23 seconds. Most points along the center line in South America will experience three to four minutes of totality. Coupled with the views of the Southern Hemisphere skies eclipse chasers will be able to enjoy, the November 3 total eclipse is likely to attract astronomers from around the world.

For more information about this eclipse, see the November 1993 issue of ASTRONOMY.

This month all of North America will see a penumbral eclipse of the Moon. For over four hours, the Moon will travel through the outer part of Earth's shadow. The eclipse begins at 11:25 p.m. Eastern Standard Time on November 17 and ends at 4:02 a.m. EST on November 18. Around mid-eclipse at 1:43 a.m. EDT keen-eyed observers may be able to detect a darkening of the Full Moon's disk, but the effect, as in all penumbral eclipses, will be subtle.

Jeff Schroeder



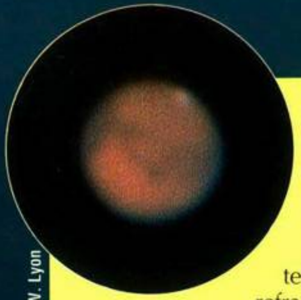
DECEMBER

S	M	T	W	T	F	S
				1	2 ●	3
4	5	6	7	8	9 ◑	10
11	12	13	14	15	16	17
18 ○	19	20	21	22	23	24
25 ◐	26	27	28	29	30	31

Day	Hour (UT)	
5	19	Neptune 4° S. of waxing crescent Moon (evening)
6	0	Uranus 6° S. of waxing crescent Moon (evening)
8	**8**	**Mars 2° N. of Regulus (morning)**
9	5	Saturn 7° S. of First Quarter Moon (evening)
	11	!! Venus at greatest brilliancy (mag. –4.7, morning)
14	4	Geminid meteors (waxing gibbous Moon)
20	**—**	**!! Disk of Mars exceeds 10" (prime viewing season opens)**
22	2	Solstice (northern winter/southern summer begins)
23	15	Mars 9° N. of waning gibbous Moon (morning)
24	**—**	**!! Jupiter 0.25° S. of mag. 2.6 star Beta Scorpii** (only close approach to Beta Sco in planet's 1994/95 apparition)
25	2	Asteroid 4 Vesta at opposition
29	**5**	**!! Venus 3° N. of crescent Moon (morning)**
30	**0**	**!! Jupiter 1.1° S. of waning crescent Moon (morning, occultation visible from Asia)**

Events in **bold** are good astrophotography targets.
Events marked **!!** are celestial highlights not to be missed.

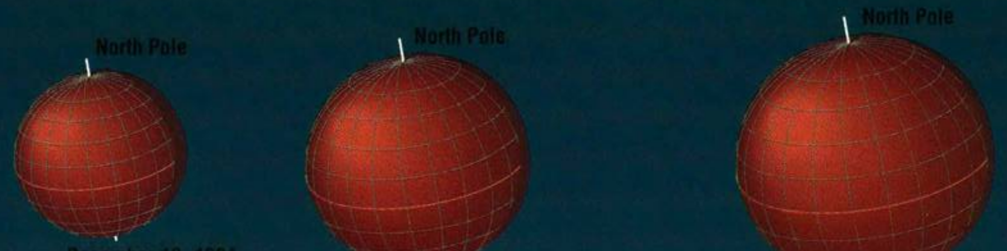
BEGIN A WINTER MARS WATCH



D. W. Lyon

Every two years, Mars comes close to Earth and appears at its best through a telescope. In late 1994, Mars begins its next biennial apparition, with the Red Planet closest to Earth on February 11, 1995. At that time Mars will be 101 million kilometers away and its disk will appear 13.8" across. To begin to see detail on Mars, a good rule of thumb is that the disk of Mars must be at least 10" across. Mars passes that milestone on December 20.

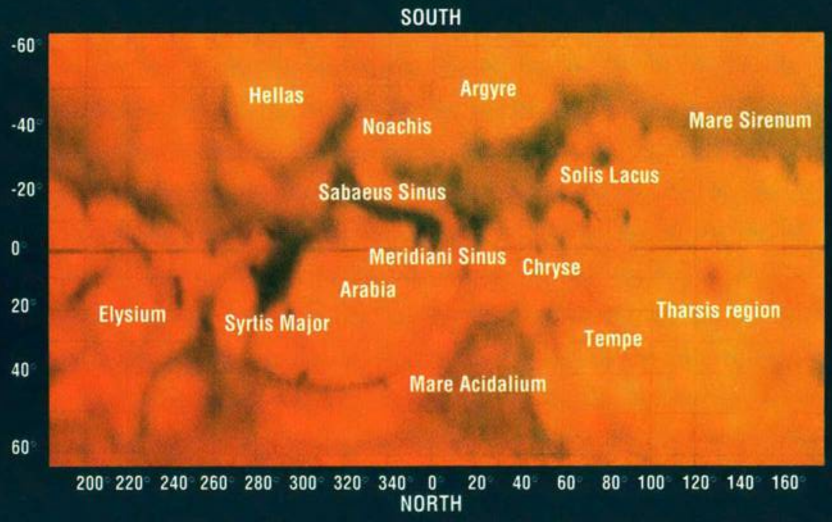
To get the most out of your winter Mars watch, be sure to use a well-collimated telescope that you have allowed to cool down to the ambient night temperature. A 3-inch refractor or 4-inch reflector will show details such as the polar caps and largest dark markings, but a good 6-inch scope is usually considered the minimum for exploring the Red Planet. A #21 orange or #23A red filter also does wonders to enhance the contrast and bring out the dark markings.


North Pole
North Pole
North Pole

December 12, 1994
Size of disk = 9.4"
Magnitude = 0.1

January 12, 1995
Size of disk = 12.2"
Magnitude = -0.5

February 12, 1995
Size of disk = 13.7"
Magnitude = -0.7


SOUTH
NORTH
-60°
-40°
-20°
0
20°
40°
60°
200° 220° 240° 260° 280° 300° 320° 340° 0 20 40 60 80 100 120 140 160°
Hellas
Argyre
Noachis
Mare Sirenum
Sabaeus Sinus
Solis Lacus
Meridiani Sinus
Chryse
Arabia
Elysium
Syrtis Major
Tharsis region
Tempe
Mare Acidalium

MARTIAN CENTRAL MERIDIANS

The following longitudes will be centered on the Martian disk at 0h UT.

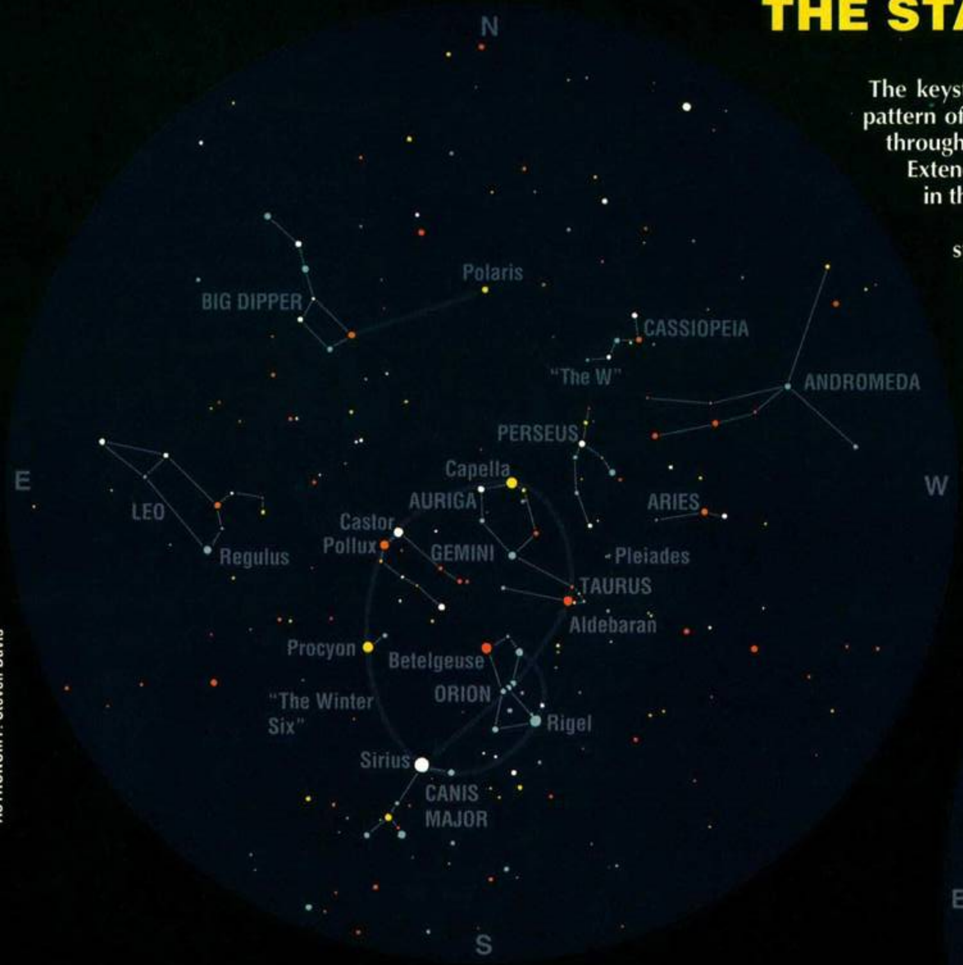
Nov. 28	98°	Dec. 16	289°
Dec. 1	70°	Dec. 19	261°
Dec. 4	42°	Dec. 22	233°
Dec. 7	13°	Dec. 25	206°
Dec. 10	345°	Dec. 28	178°
Dec. 13	317°	Dec. 31	151°

Subtract 9.1° for each day after a listed date, and add 14.6° for each hour after 0h UT.

THE STARS OF WINTER

The keystone of the winter night sky is the constellation Orion the Hunter. Look for a distinctive pattern of three stars in a row due south in the winter sky. This is Orion's Belt. A straight line drawn through the Belt and extended upward brings you to Aldebaran, the reddish eye of Taurus the Bull. Extend the line down from the Belt and you come to Canis Major and the star Sirius, the brightest in the night sky.

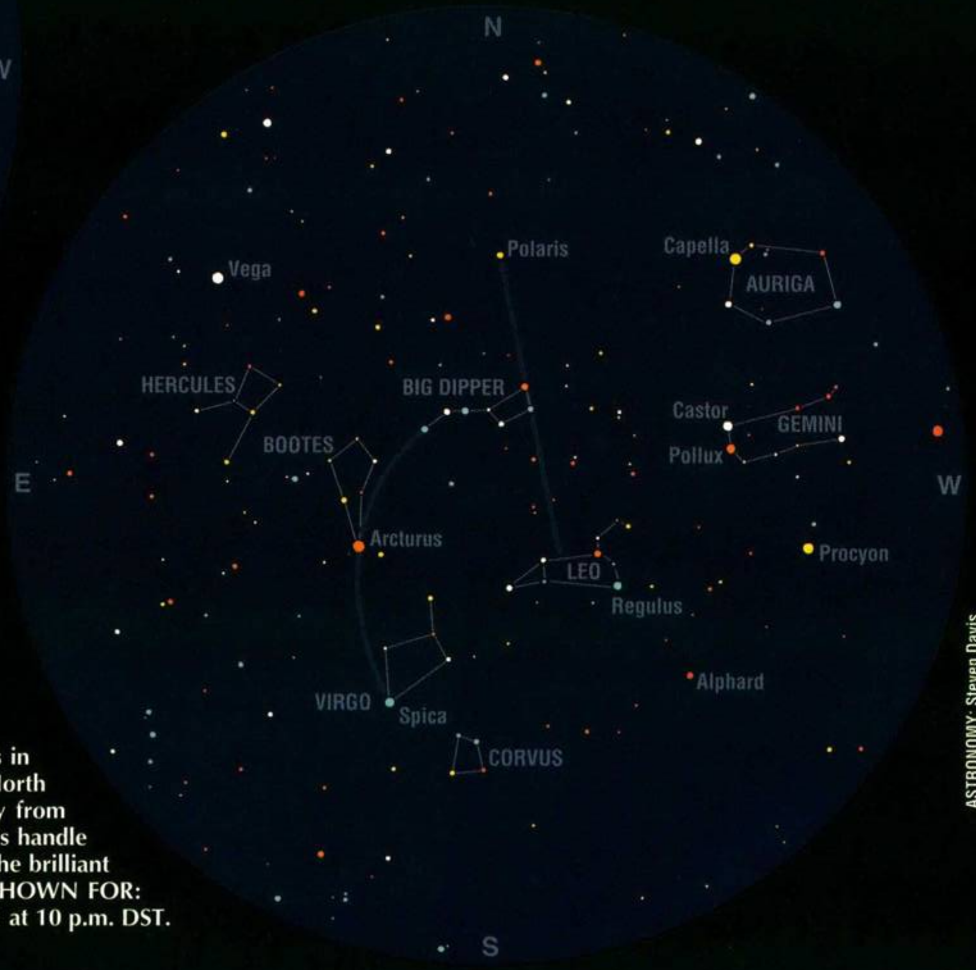
Surrounding Orion is a group of bright stars that form a "6." To trace out the "Winter Six" start with Aldebaran and then curve up to Capella, then down to the twin stars of Castor and Pollux. Follow the circle to Procyon, down to Sirius, then back up to Rigel and Betelgeuse in Orion. Late in 1994, you'll see Mars as an additional bright red "star" between Gemini and Leo. SKY SHOWN FOR: January 1 at 11 p.m., January 15 at 10 p.m., February 1 at 9 p.m., February 15 at 8 p.m., March 1 at 7 p.m. Latitude = 40° N.


N
E
W
S
BIG DIPPER
Polaris
CASSIOPEIA
"The W"
ANDROMEDA
PERSEUS
Capella
AURIGA
ARIES
LEO
Castor
Pollux
GEMINI
Pleiades
TAURUS
Aldebaran
Regulus
Procyon
Betelgeuse
ORION
"The Winter Six"
Rigel
Sirius
CANIS MAJOR

ASTRONOMY: Steven Davis

THE STARS OF SPRING

On spring nights the Big Dipper lies high overhead. A line drawn through the two stars in the pouring edge of the Dipper's bowl and extended to the north points to Polaris, the North Star. If you extend a line from the Dipper's Pointer stars in the opposite direction away from Polaris you come to Leo the Lion and its bright star Regulus. Follow the arc of the Dipper's handle and you come to Arcturus in Bootes. Continue the arc south and you find Spica in Virgo. The brilliant object to the east of Spica this spring is Jupiter, a fine target for a small telescope. SKY SHOWN FOR: March 1 at 1 a.m., March 15 at midnight, April 1 at 11 p.m., April 15 at 11 p.m. DST, May 1 at 10 p.m. DST.

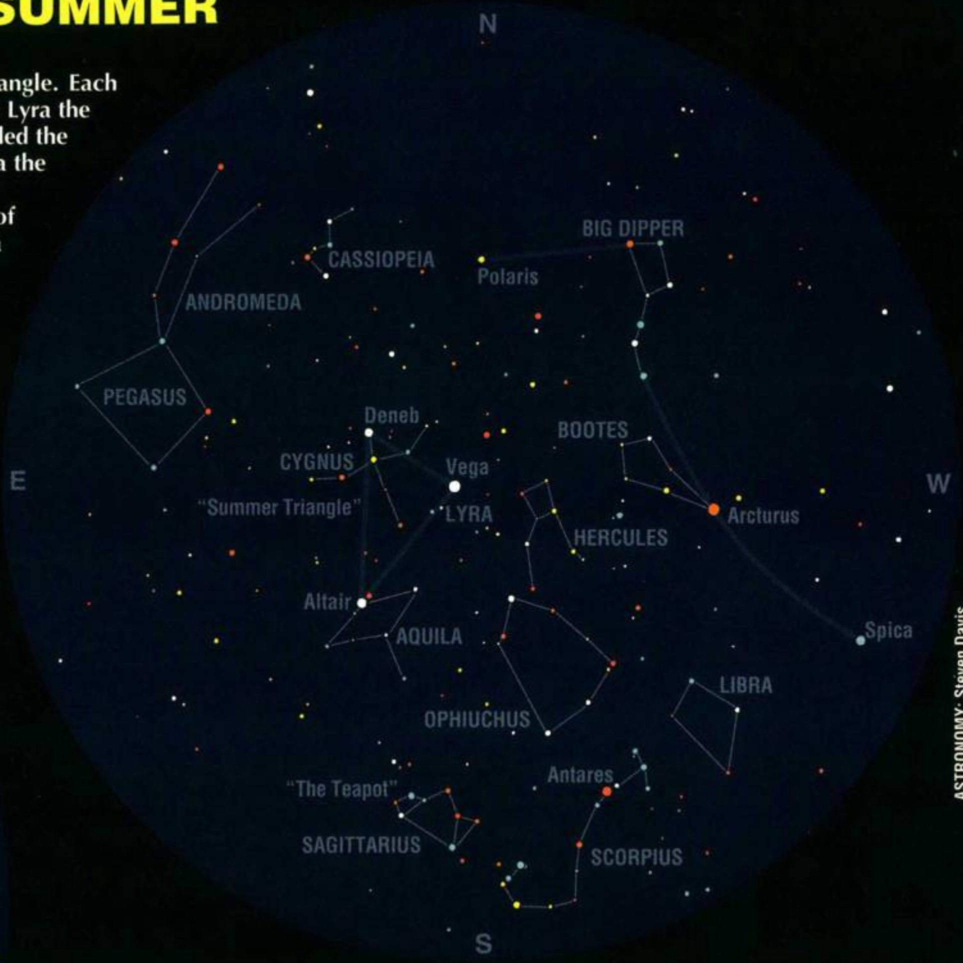

N
E
W
S
Polaris
Capella
AURIGA
Vega
HERCULES
BIG DIPPER
BOOTES
Castor
GEMINI
Pollux
Arcturus
LEO
Regulus
Procyon
Alphard
VIRGO
Spica
CORVUS

ASTRONOMY: Steven Davis

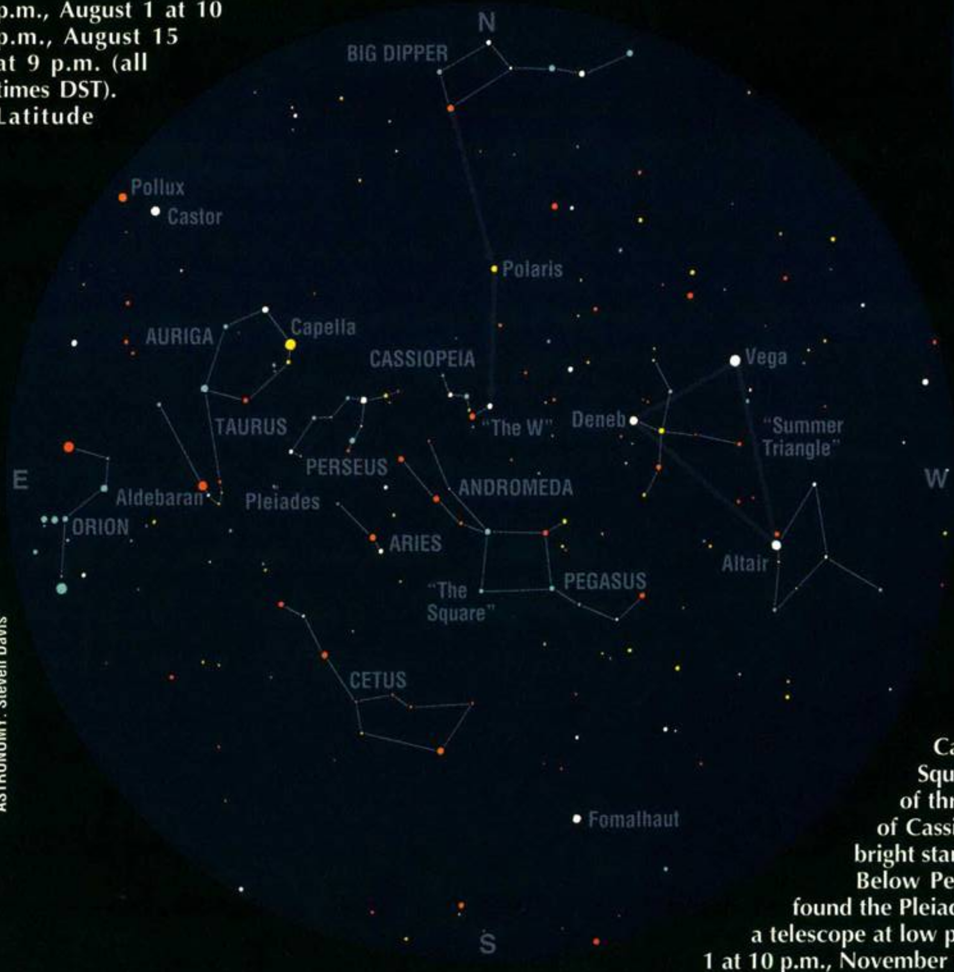
THE STARS OF SUMMER

High overhead look for a trio of bright stars forming a pattern called the Summer Triangle. Each belongs to a separate constellation. Farthest to the west is blue-white Vega in the constellation Lyra the Harp. To the east is Deneb, the star that forms the tail of Cygnus the Swan, a pattern often called the Northern Cross. The Summer Triangle star down in the south is Altair, the bright eye of Aquila the Eagle.

Along the southern horizon look for a bright reddish star. That's Antares, the heart of Scorpius the Scorpion. Just to the east, try to trace out a pattern of stars that resembles a teapot. Although the pattern is supposed to represent an archer, the teapot shape is what everyone looks for when picking out the constellation Sagittarius. Well to the east of Sagittarius, you'll see a lone bright "star" this summer. Train a telescope at it and you'll discover that it's Saturn, surrounded by its glorious rings. SKY SHOWN FOR: June 1 at 2 a.m., June 15 at 1 a.m., July 1 at midnight, July 15 at 11 p.m., August 1 at 10 p.m., August 15 at 9 p.m. (all times DST). Latitude


N
BIG DIPPER
CASSIOPEIA
Polaris
ANDROMEDA
PEGASUS
Deneb
CYGNUS
E
"Summer Triangle"
Vega
LYRA
BOOTES
W
HERCULES
Arcturus
Altair
AQUILA
Spica
LIBRA
OPHIUCHUS
Antares
"The Teapot"
SAGITTARIUS
SCORPIUS
S

ASTRONOMY: Steven Davis

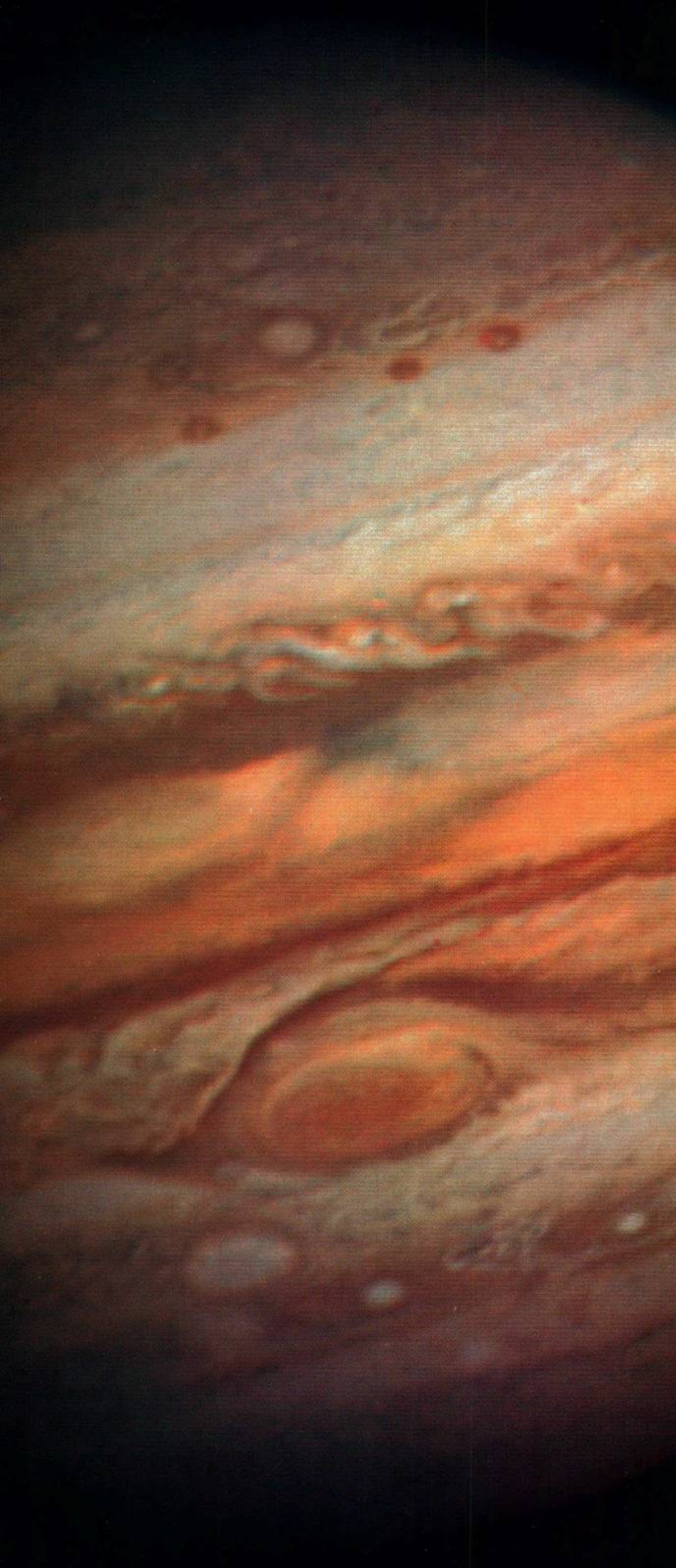

N
BIG DIPPER
Pollux
Castor
Polaris
AURIGA
Capella
CASSIOPEIA
Vega
TAURUS
"The W"
Deneb
"Summer Triangle"
PERSEUS
E
Aldebaran
Pleiades
ANDROMEDA
W
ORION
ARIES
Altair
"The Square"
PEGASUS
CETUS
Fomalhaut
S

ASTRONOMY: Steven Davis

THE STARS OF AUTUMN

The "W" pattern of stars now high overhead at night is Cassiopeia the Queen. Below Cassiopeia in the southern half of the sky, look for a square of four fairly bright stars. The Great Square marks Pegasus the Flying Horse. Extending from the top left corner of the Square is an arc of three bright stars that curves back toward Cassiopeia. The arc marks Andromeda, the daughter of Cassiopeia who was rescued by Perseus the Hero. Perseus can be found in a loose collection of bright stars off the north end of the arc of Andromeda and below the left side of the W of Cassiopeia.

Below Perseus, you can see a tight cluster of stars rising in the east late on autumn nights. You've found the Pleiades star cluster, or "Seven Sisters," a deep-sky object well worth a look through binoculars or a telescope at low power. SKY SHOWN FOR: October 1 at 1 a.m. DST, October 15 at midnight DST, November 1 at 10 p.m., November 15 at 9 p.m., December 1 at 8 p.m. Latitude = 40° N.



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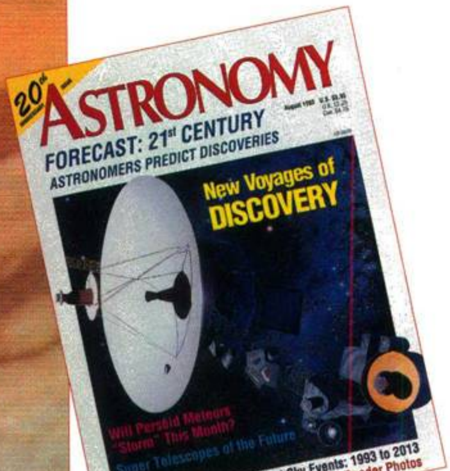
20th
ASTRONOMY
FORECAST: 21st CENTURY
ASTRONOMERS PREDICT DISCOVERIES
New Voyages of DISCOVERY
Will Perseid Meteors "Storm" This Month?
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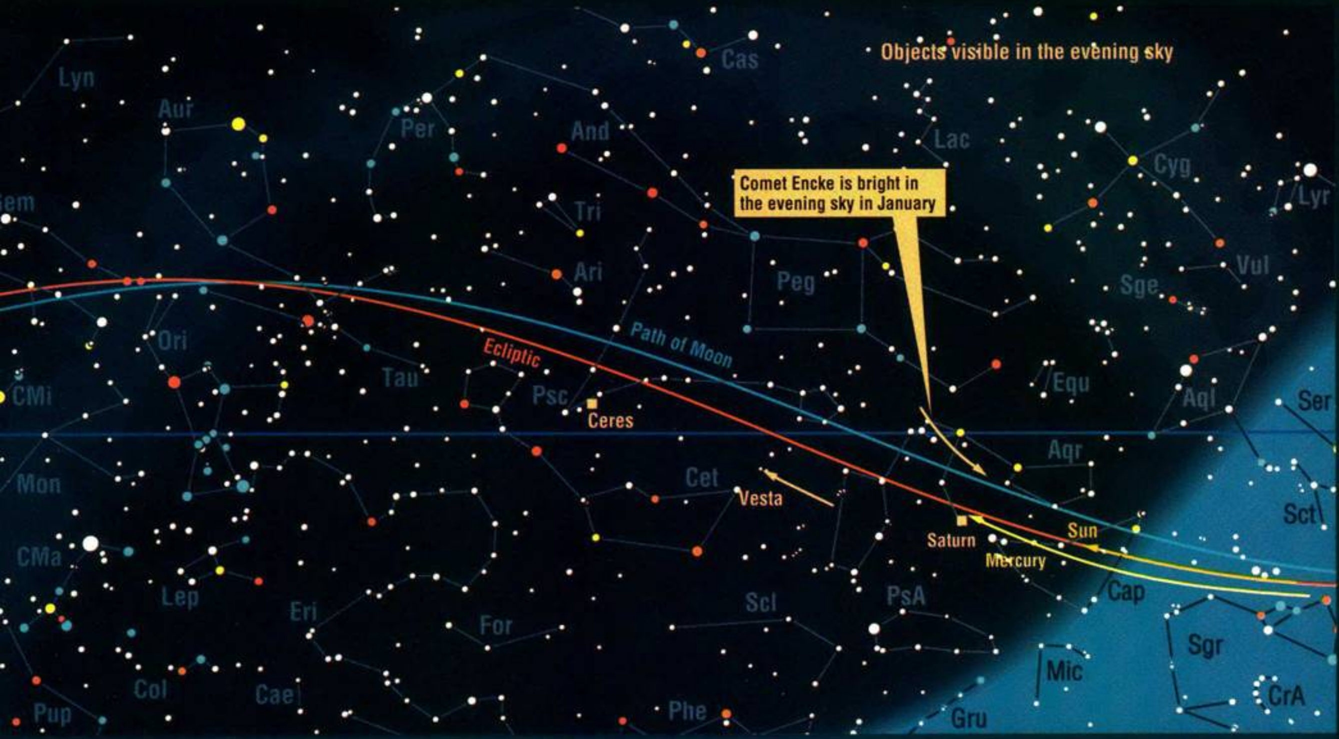

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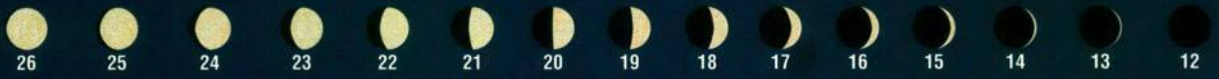
Objects visible in the evening sky

Comet Encke is bright in the evening sky in January



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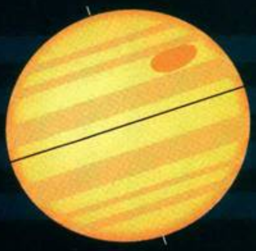
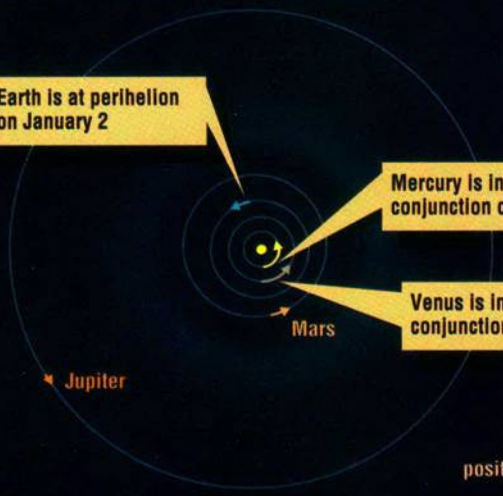


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
January 15	January 15	January 15	January 15	January 15
−1.9	0.9	5.8	8.0	13.8
34.9"	15.7"	3.4"	2.2"	0.1"
99%	100%	100%	100%	100%
5.651	10.577	20.618	31.162	30.270
5.443	9.775	19.635	30.181	29.764
14h38.9m	22h04.7m	19h37.5m	19h30.7m	15h53.6m
−14°16	−13°19'	−22°01'	−21°11'	−6°07'

THE PLANETS IN THEIR ORBITS



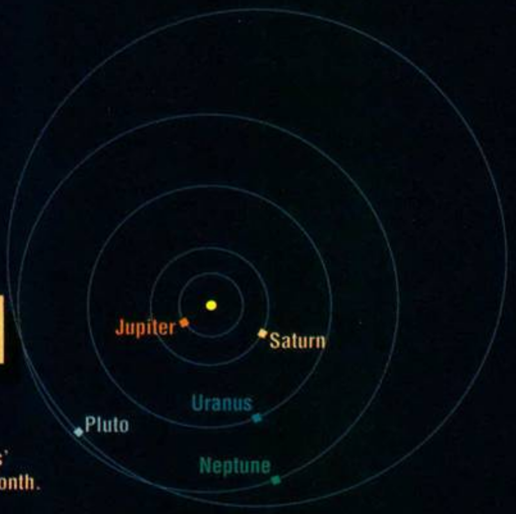
Mars
Jupiter

Earth is at perihelion on January 2

Mercury is in superior conjunction on January 3

Venus is in superior conjunction on January 16

Arrows and dots represent planets' positions during the month.



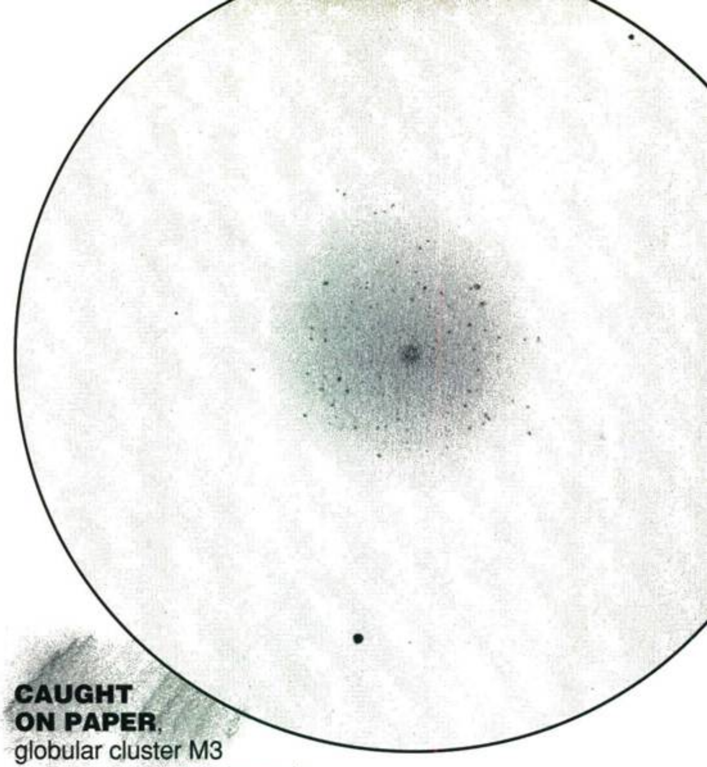
Jupiter
Saturn
Uranus
Pluto
Neptune

OBSERVING TECHNIQUES

Sketching the Deep Sky

You don't need to be Michelangelo to record the sky's greatest objects. Grab pencil and paper and head for the stars.

Text and artwork by Lee T. Macdonald



CAUGHT ON PAPER, globular cluster M3 in Canes Venatici shows its appearance through an 8-inch telescope at 130x.

Thanks to the widespread availability of large telescopes and the revolution in astronomical information, it's easy to view clusters and nebulae quickly. Too often deep-sky observers look but don't see. To get the most enjoyment out of deep-sky viewing, you need to observe critically, which over time sharpens your eye and makes you a better observer. You also need to record your observations so you can refer to them later. Sketching deep-sky objects with pencil and paper accomplishes both goals. And despite what you may think, it's easy.

The next time you're out with some observing buddies, get several people to sketch the same cluster, nebula, or galaxy with the same instrument. Each drawing will be different from the others because every observer sees things in a distinct way, and this makes drawings fun to compare.

But if the participants keep drawing deep-sky objects and come back a year later, the test will come out very differently. The experience gained by the observers will make their sketches depict the object more accurately. For example, if you sketch a globular cluster one year, your drawing may show few individual stars. Next year, you'll record some more in that same cluster, and the year after that you may draw hundreds of stars in it. Over a period of time sketching enables you to see many more features in each cluster, nebula, or galaxy.

But photographs show much more detail than drawings ever could, right? Not exactly. While photographs capture much more faint nebulosity surrounding the bright core of a galaxy or nebula, the core itself is usually so overexposed that all detail is lost. Even techniques like unsharp masking and CCD imaging show less detail than a sketch made by an experienced observer. Sketching is also much quicker and cheaper than astrophotography. The $20 or so you spend on sketching materials is 1/100 of what you could spend on high-tech photo gear.

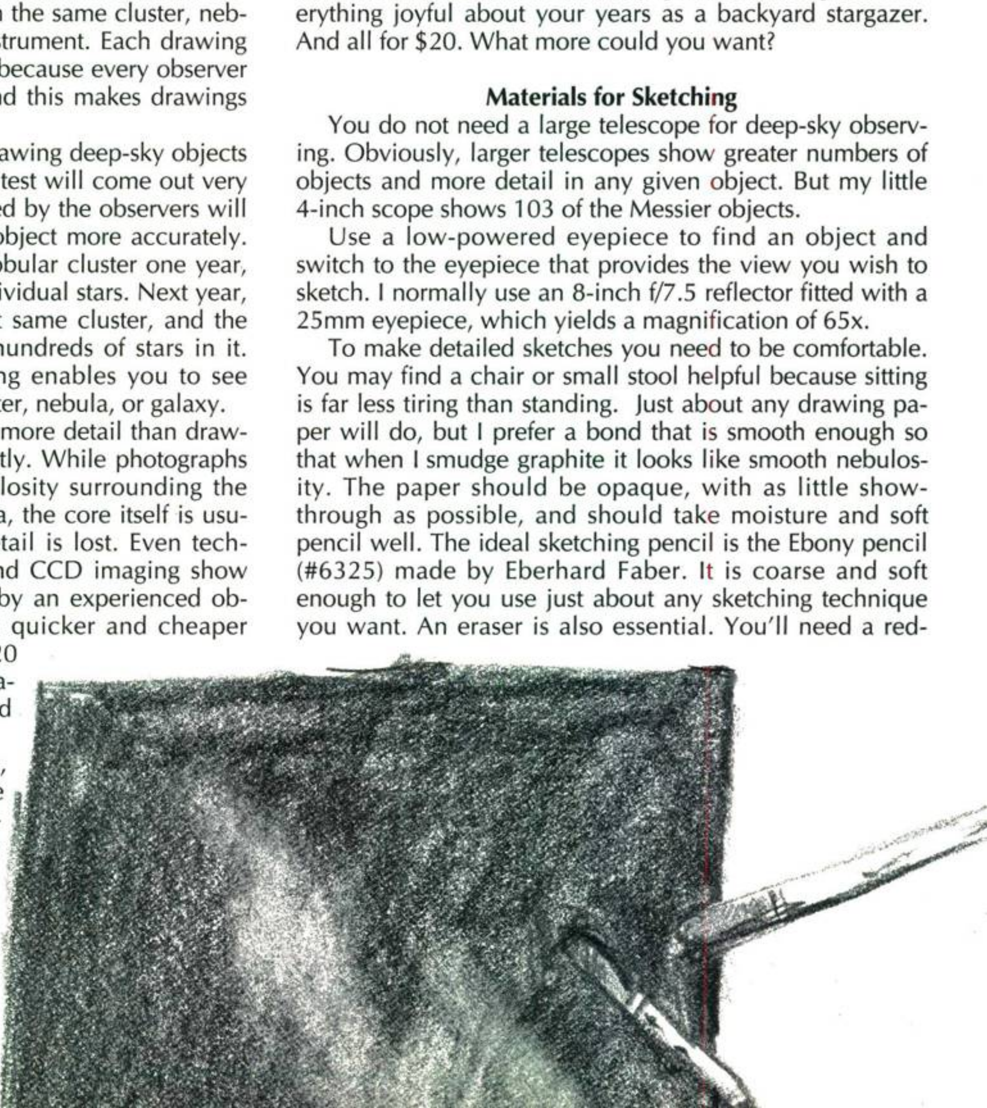
More importantly, however, drawings depict what you see through the *eyepiece* — something that photos and CCDs can never do, regardless of the detail they pick up. This visual record will be priceless in years to come, not only as something to pull out and study as you reminisce about the objects you've observed, but also as a memory jog that will bring back everything joyful about your years as a backyard stargazer. And all for $20. What more could you want?

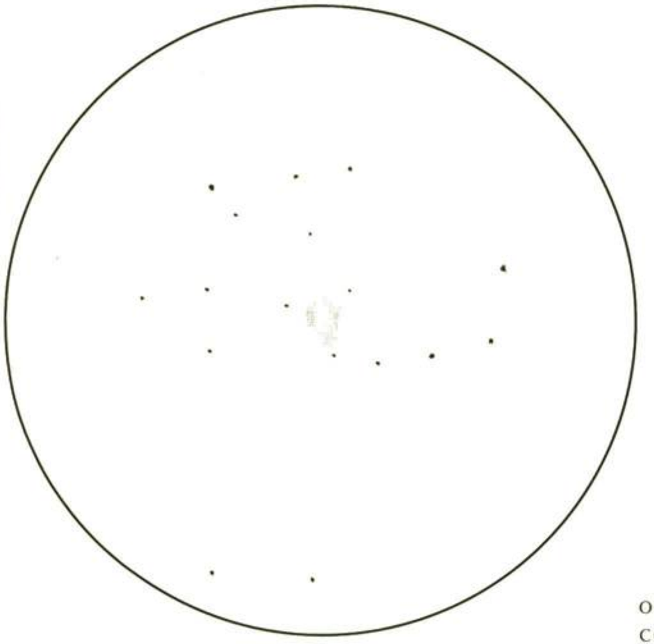
Materials for Sketching

You do not need a large telescope for deep-sky observing. Obviously, larger telescopes show greater numbers of objects and more detail in any given object. But my little 4-inch scope shows 103 of the Messier objects.

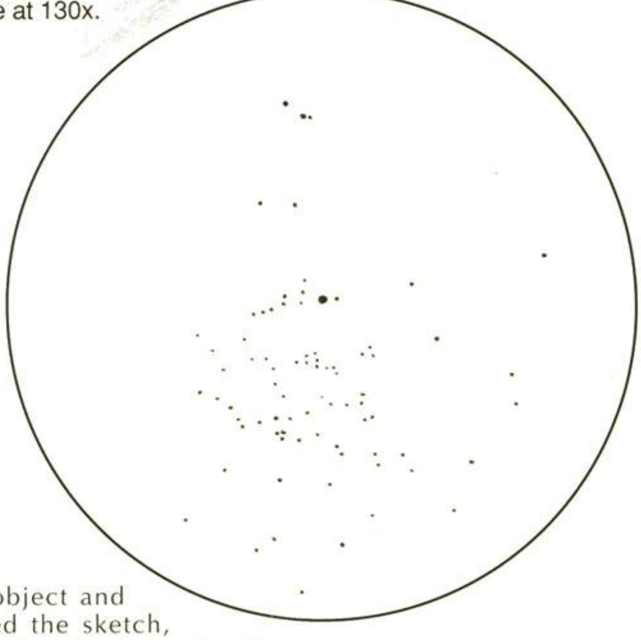
Use a low-powered eyepiece to find an object and switch to the eyepiece that provides the view you wish to sketch. I normally use an 8-inch f/7.5 reflector fitted with a 25mm eyepiece, which yields a magnification of 65x.

To make detailed sketches you need to be comfortable. You may find a chair or small stool helpful because sitting is far less tiring than standing. Just about any drawing paper will do, but I prefer a bond that is smooth enough so that when I smudge graphite it looks like smooth nebulosity. The paper should be opaque, with as little show-through as possible, and should take moisture and soft pencil well. The ideal sketching pencil is the Ebony pencil (#6325) made by Eberhard Faber. It is coarse and soft enough to let you use just about any sketching technique you want. An eraser is also essential. You'll need a red-





THE RING NEBULA in Lyra is a tiny smoke-ring of nebulosity as sketched with an 8-inch scope at 130x.



PLOTTING STARS creates a portrait of the open star cluster M11 in Scutum, nicknamed the Wild Duck Cluster. Sketch made with an 8-inch scope at 130x.

filtered flashlight to illuminate your sketch while drawing. White light is no good — it will ruin your dark adaptation even if you glance at it briefly.

It's a good idea to set up a table next to your telescope and chair to avoid fumbling with accessories in the dark. Any type of card table or bench will do, as long as it provides enough room for you to spread out materials.

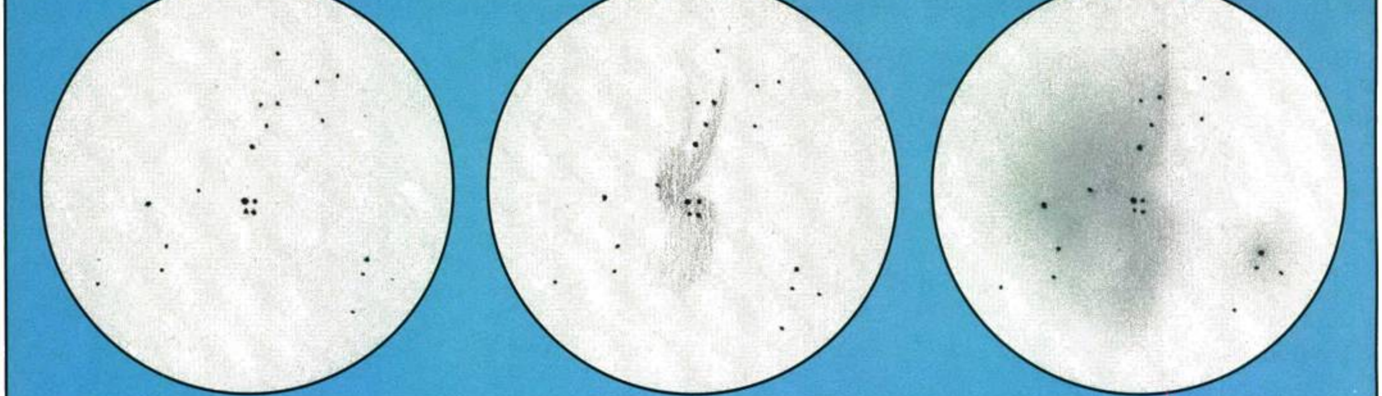
Sketching Techniques

Once you've located your target, examine it carefully for several minutes. This acquaints you with the object and lets you study the star patterns in the field of view. Next, record the details that will accompany your sketch. These include the date, the time, your telescope and magnification, any filters you may use, and observing conditions. Record the common name and catalog numbers of the object you're sketching. The sky darkness, seeing, and transparency of the sky are critically important because they affect what you can observe in a given telescope.

If you can, note the faintest star you can see with the naked eye and record its magnitude. That gives you a measure of sky darkness. Try to rate seeing, atmospheric steadiness, on a scale of one through five. You can rate transparency, the clarity of the atmosphere, on a similar scale. Getting this calibrated in your mind will take some time, but once you learn the skill it will never go away. Once you've absorbed the image of your object and completed the sketch, you'll want to make a few notes of your impressions.

With those things in mind, you're ready to begin sketching. Your circle representing the eyepiece field of view should be large enough to include sufficient detail but small enough so you can finish the sketch in a reasonable time. Something like three to four inches in diameter works best. Take the pencil and carefully plot the stars in the field, working from brightest to faintest. Make the range of sizes small: Even bright stars are point sources, so you don't want to draw them as large disks on the paper. Continue plotting fainter stars, measuring distances and geometric patterns relative to the bright stars, until you've included all stars you can see.

If you're drawing an open cluster, you're done at this stage. But if you're sketching a nebulous object — a galaxy, nebula, or globular cluster — you need to apply some graphite, lightly, to the area where you see the fuzzy light. As you do this, generally match the shape of the object. Globulars require a circular motion of the pencil, which becomes progressively softer outward from the



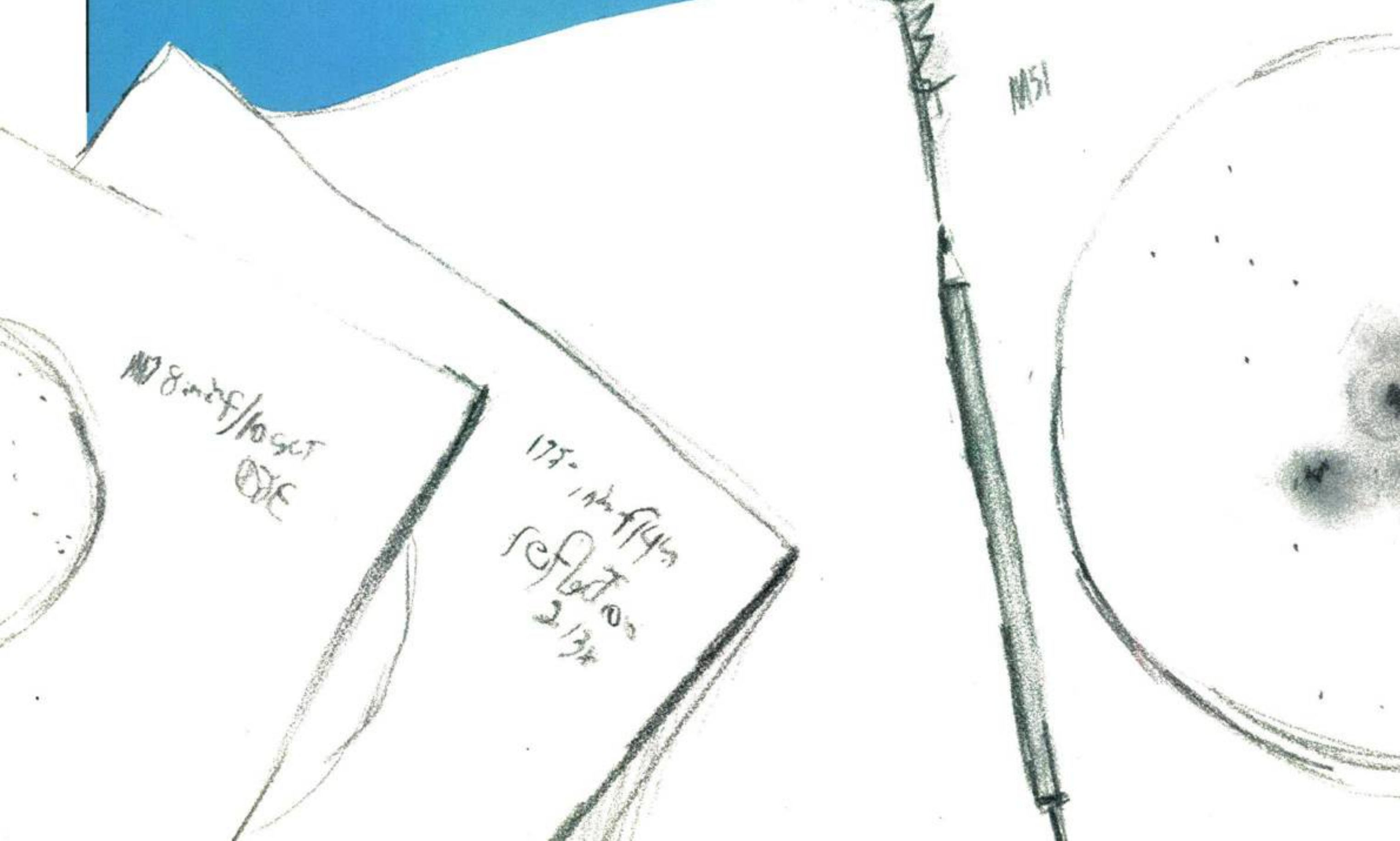
The making of a deep-sky sketch

Creating a deep-sky sketch with pencil and paper is much easier than most backyard astronomers believe. In fact it is basically mechanical, requiring little artistic talent. Once you've set up your scope, assembled your supplies, dark-adapted your eyes, and found your object, sketching consists of three simple steps.

Step 1: Slowly and methodically plot the stars you see in the field of view, working from the brightest stars to the faintest, as in this sketch of the Orion Nebula. To begin with, mentally measure the distances between stars and the edge of the field to place the brightest stars accurately. Next, fill in progressively fainter stars, carefully noting their positions relative to bright stars and within geometric patterns, until you've sketched all of the stars you can see.

Step 2: Hold your pencil with the exposed graphite nearly parallel to the paper. Lay down some graphite very gingerly to approximate the shape of the fuzzy glow you see in the eyepiece.

Step 3: Now the tricky part: moisten your index finger very lightly and use it to smudge the graphite to mimic the shape of the object more accurately. You may need to use an eraser to shape the object and to add dark features and you'll want to go over the final details with a sharp pencil. Voilà!

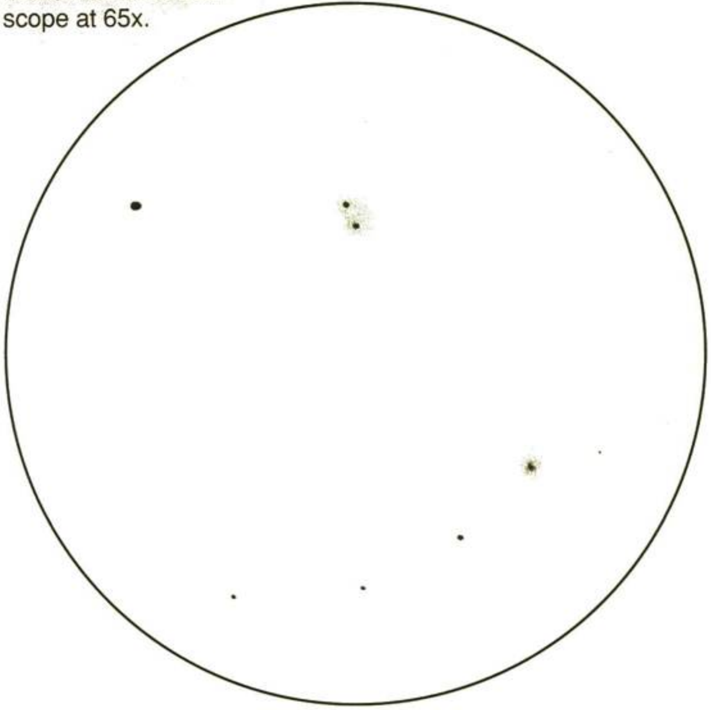


center. This also applies to many galaxies. In both cases, be sure you plot the center of the cluster or galaxy in the correct position in relation to the stars — otherwise, you'll have a lot of erasing to do. For nebulae, carefully shade the brightest parts in relation to the stars you have plotted. Always hold the pencil so that the exposed graphite is nearly parallel to the paper. In this way, you'll lay down a smooth coverage that approximates the appearance of the object.

Now you're ready for the "artistic" step of deep-sky sketching. Wet your index finger with the merest hint of moisture and use it to smudge the graphite so that you match the shape, brightness, and distribution of light over the object. This is subtle. It's surprising how little smudging is necessary to produce a good sketch. If your object becomes too dark, you've applied too much moisture and you'll need to erase and repeat the process. You'll also need the eraser to finish shaping the object, to add any dark lanes that may exist, and to clean up the final result. You may also need to add finishing details with the pencil after smudging, details such as a galaxy's bright, starlike nucleus or stars that lie within a faint wisp of nebulosity.

Congratulations — you've made your first deep-sky sketch. Take another careful eyepiece look, comparing it with the drawing. You may want to add fine details or do a little touch up so it conforms to the eyepiece view. At this stage I often boost the contrast of faint tendrils of nebulosity or the spiral arms of galaxies. Dust lanes and areas of dark nebulosity should be very carefully rubbed out and then smudged. A soft eraser, cut so that one end goes to a point, makes this task relatively easy.

THE FUZZY GLOW of reflection nebulae M78 (above center) and nearby NGC 2071 stands out in this sketch made with an 8-inch scope at 65x.



16
17.5" f/4.5
32mm

Preserving Your Keepsakes

Don't feel bad if for the first few weeks your original eyepiece drawings look a little rough in the harsh light of day. You may want to make a finished sketch later consisting of a copy, made more neatly, of the original field drawing. You can do this by making a freehand copy and inking in the stars as round, black dots. If you make copies, however, be careful not to alter details of the object.

Your sketches will form a great part of your library to enjoy in future years. You may also wish to send copies to publications that might share them with other observers. These include ASTRONOMY and the more specialized periodicals *Deep Sky Journal* (6210 Karjala Road, Aberdeen, WA 98520), *Betelgeuse* (published by the National Deep Sky Observers Society, 1607 Washington Blvd., Louisville, KY 40242), and *The Deep Sky Observer* (published by the Webb Society, 12 Burton Close, Windlesham, Surrey GU20 6QJ, England).

Deep-sky sketching adds a new dimension to observing. As it trains your eye to see more detail, you will soon realize there is really something to deep-sky observing. Globular clusters won't all look the same and galaxies will not appear as simple blobs in the eyepiece. You'll be able to share your views of the heavens with others without the expense of astrophotography. But most important, sketching deep-sky objects captures the beauty of deep-sky objects and lets you store it on your bookshelf for decades to come. □

Lee T. Macdonald is an avid deep-sky observer living in Newbury, Berkshire, England. This is his first article in ASTRONOMY.

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WANTED. *Farout* magazine (issues #2 and #3). Contact Dan Isaac, 1122 Lowgap Road, Danville, WV 25053, (304) 369-2216.

FOR SALE. Newtonian 14.5" f/5.5 Galaxy OTA on Cave model D Observatory G.E.M., ideal for small institution or advanced amateur; $8,900 (or best offer) plus shipping. Send SASE for photo and additional information. Contact Bob Yoesle, P.O. Box 261, La Center, WA 98629, (206) 263-3879.

FOR SALE. 10" f/6 Galaxy mirror, 2.25" E & W Cervit diagonal. Both with enhanced aluminum. Novak cell, spider, diagonal holder, and 2" rack and pinion focuser; $500. JMI Motofocus for Newtonian focuser; $75. Folded 4" f/15 refractor on Super Polaris mount with RA and DEC motors and optical encoders; $1,200. Contact Steve Mock (617) 625-5870.

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WANTED. Back issues of *Sky & Telescope.* Specifically looking for issues prior to 1955, all of 1958 and 1959, and Jan., Feb., March, July, Oct., and Dec. of 1960. Contact Dale Mais, 15219 Cool Valley Road, Valley Center, CA 92082, (619) 751-1156.

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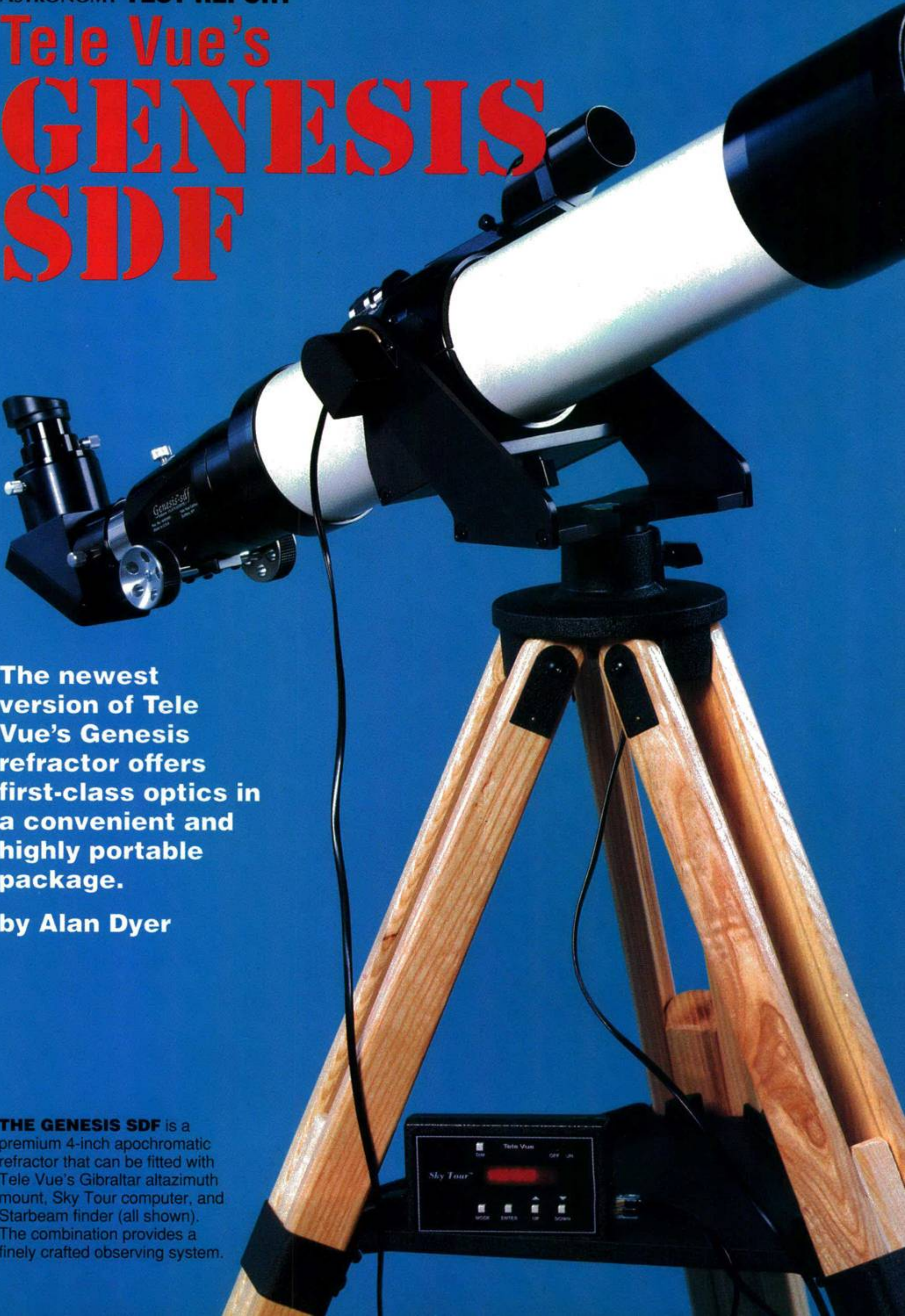
ASTRONOMY **TEST REPORT**

Tele Vue's GENESIS SDF

The newest version of Tele Vue's Genesis refractor offers first-class optics in a convenient and highly portable package.

by Alan Dyer


Genesis-sdf
Tele Vue
Sky Tour
OFF ON
MODE
ENTER
UP
DOWN

THE GENESIS SDF is a premium 4-inch apochromatic refractor that can be fitted with Tele Vue's Gibraltar altazimuth mount, Sky Tour computer, and Starbeam finder (all shown). The combination provides a finely crafted observing system.

Over the last decade Tele Vue has built a reputation as a supplier of fine optics. Known for its popular wide-angle and Plössl eyepieces, Tele Vue has also championed the apochromatic refractor. Its early MPT (the Multi-Purpose Telescope, a 5-inch f/4 refractor) and 4-inch Renaissance helped establish the premium refractor in today's marketplace. The Genesis refractor introduced in 1988 improved upon the earlier models by reducing the bugbear of all refractors, false color or chromatic aberration.

Now, Tele Vue has taken the Genesis design one step further by introducing the Genesis SDF, the latest model in their refractor line. Testing a unit on loan from the manufacturer, I found the SDF offers a significant reduction of chromatic aberration while retaining all the best features of earlier Tele Vue refractors — exquisite construction quality, compactness, and a wide, flat field.

TELE VUE GENESIS SDF

STANDARD SPECIFICATIONS

Aperture	4 inches
Focal ratio	f/5.4
Focal length	540 mm
Length of tube	33 inches
Closest focus	10 feet
Size of focuser	2 inches
Included 1.25-inch eyepiece	17 mm (Plössl 32x)
Photographic field (35mm film)	2.5° x 3.8°
Weight of optical tube assembly	11 lbs.
Weight of tube and Gibraltar	30 lbs.
Warranty	5 years
Suggested list price	$2,695
Typical retail price	$2,000

(Includes eyepiece, 2-inch star diagonal, 1.25-inch adapter, dewcap, metal lens cap, mounting ring, and padded hardshell case for tube assembly, eyepieces, diagonal, Starbeam, and Sky Tour.)

Tele Vue Optics, Inc., Dept. A, 100 Route 59, Suffern, NY 10901, (914) 357-9522.

OPTIONAL ACCESSORIES

(Suggested list prices; actual retail prices vary with dealer)

Gibraltar altazimuth mount	$595
Starbeam unit-power finder	$250
Sky Tour computer and encoders	TBA
Air Chair seat (shown above)	$130
Basic camera adapter	$50
Eyepiece projection adapter	$95
Solar kit (requires H-α filter)	$795

Also available:
Eyepieces, Barlows, and adapter plates for equatorial mounts.

The Optics

The 4-inch-aperture Genesis SDF uses the same basic optical configuration as the standard Genesis, the Renaissance, and the original MPT. The design consists of a two-element front objective combined with a two-element corrector lens at the rear of the telescope.

In the Genesis and Genesis SDF, the rear corrector lens pair is about two inches in diameter. This corrector flattens the field of view of the telescope, eliminating the curvature of field common in many fast refractors. This aberration can make stars at the edge of a wide-angle eyepiece or at the edge of a film frame appear out of focus or astigmatic.

The corrector also serves as a telecompressor. While the SDF is an f/5.4 telescope, the front objective actually has a longer f/ratio, closer to f/12. The rear lens group speeds up the f/ratio of the telescope, providing a wide field for deep-sky viewing and short exposure times for deep-sky astrophotography. (Astrophotography requires placing the Genesis on an equatorial mount.)

Normally, fast achromatic refractors exhibit false color in the form of blue halos around bright stars and planets. The standard Genesis reduced this false color to low levels by incorporating a fluorite lens as one of the elements of the rear corrector group. The fluorite employed in lenses is an artificially grown crystal with low dispersion characteristics that has been used for years to create top-of-the-line refractors.

The new SDF goes one better by retaining the fluorite element (the "f" in SDF) and using what Tele Vue calls "special dispersion" glasses for the front lens elements (the "sd" in SDF). It's not clear if these glasses are what the industry calls ED glasses (Extra-low Dispersion) — Tele Vue's president and optical designer Al Nagler prefers to keep the design of the front-element glasses proprietary.

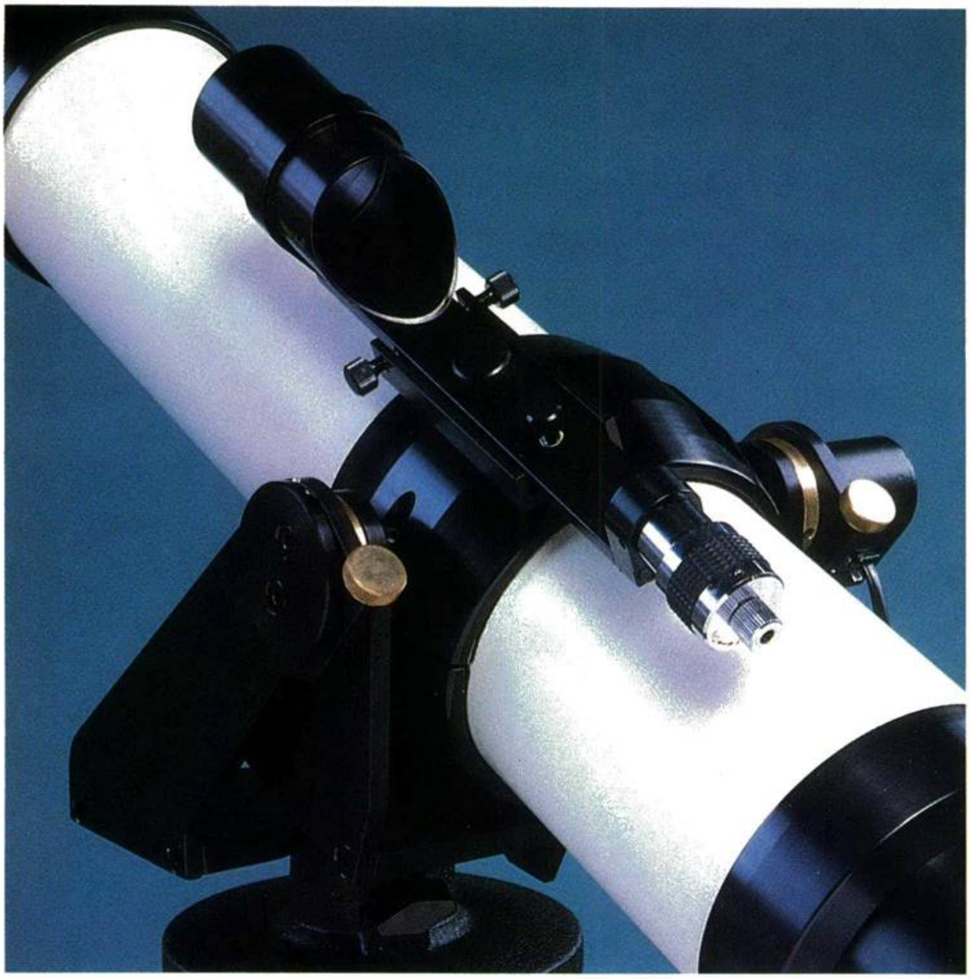
Nagler points out that a benefit of the Genesis design is that he can fine-tune each unit's performance by varying the roughly 12mm air space between the front elements or 1mm air space between the rear elements. Tweaking each telescope's lenses helps correct for variations in the final lens curves or characteristics of the batch of glass used to make those lenses.

No matter what its design, the value of any optical system rests in how well it performs under real-world conditions. On critical star tests, the Genesis SDF performed flawlessly. At high power, it exhibited a textbook diffraction pattern in focus, with bright stars showing an immaculate Airy disk surrounded by a well-defined first diffraction ring and a trace of a second ring, just as near-perfect optics should. (An ill-defined Airy disk and bright multiple diffraction rings indicate the presence of flaws such as spherical aberration.) Faint stars at high power showed a clean Airy disk with just a trace of the first diffraction ring.

Both pairs of the double-double star Epsilon Lyrae appeared cleanly split with dark sky between the tiny, sharply defined stars. Saturn was sharp and contrasty, with the Cassini division in the rings as well as color differences in the belts and zones on the planet's disk clearly visible.

Star images exhibited not a trace of astigmatism — when thrown just slightly out of focus, star images looked round, not elliptical. Further out of focus, stars showed nearly identical diffraction patterns on either side of focus, another indication of negligible spherical aberration. There was no sign that the heat plumes or tube currents disrupted the star images as the Genesis cooled down. In fact, cool down seemed to be unnec-

ASTRONOMY: Equipment photos by Darla Evans



THE GIBRALTAR MOUNT'S tension adjustments are easy to reach when seated (gold knobs control altitude tension). The optional Starbeam finder attached to the mount made it a snap to aim the main telescope.

essary. However, I conducted star tests on mild summer nights. Cold winter conditions provide a tougher test for any telescope but my sense is the Genesis would perform well under all temperature conditions.

The level of color correction in the SDF was impressive. The edge of the Moon was pure white. Saturn appeared without any trace of a blue halo. The zero-magnitude star Vega, one of the toughest tests, showed the merest hint of a blue halo that came and went with seeing conditions. This is a superb level of color correction in any refractor, let alone one this fast and portable.

The only sign that this was a refractor showed up when stars were thrown out of focus. Outside of focus the diffraction patterns of bright stars appeared slightly blue with a pale green outer ring while inside of focus, stars appeared a pale green with a blue outer ring. These tints were very mild and represent a significant advance over earlier Tele Vue refractors.

The lens elements are multicoated with anti-reflection coatings. The tube and focuser have no baffles, but all interior components are well blackened with a textured matte black paint. Placing the Moon just out of the field showed minimal flare from scattered light. Contributing to the contrasty field was the 2-inch star diagonal. The milling on the inside of its barrels helps block scattered light, making this one of the best star diagonals I've seen.

The flat field of the Genesis was apparent when scanning star fields with Tele Vue's 35mm Panoptic eyepiece, itself optimized to provide a wide, flat field. Stars were pinpoints across most of the 4.4° field, flaring with mild astigmatism only at the edge of the field. This residual astigmatism likely originated in the eyepiece itself.

Combined with premium wide-angle eyepieces, this is a telescope capable of providing stunning low-power views of Milky Way starfields with none of the coma inherent in fast reflectors. And yet under good seeing conditions, the sharp optics will easily handle 200 to 250 power for crisp lunar and planetary views. As an added bonus, the telescope will focus down to about 10 feet (even closer with optional extension tubes), making this a versatile telescope for nature studies.

The Mounting

I tested the Genesis on Tele Vue's latest altazimuth mount, the Gibraltar, a well-crafted mount made of machined and black-anodized aluminum. The wood tripod is made of ash. The mount has no slow-motion controls but has smooth, Dobsonian-like motions, making it easy to nudge this scope every few moments to recenter the image. However, when placed on the Gibraltar, the Genesis cannot aim to within 5° or so of the zenith.

Both axes have adjustments allowing you to vary the tension — the axes can be completely free of tension or tight enough to hold the scope firmly in place even if it is out of balance. And yet even with tension applied, it is still easy to move the scope — you don't need to keep locking and unlocking the mount to find objects and track them manually.

The tripod adjusts in height over a 33-inch range. Extending the legs only 10 to 16 inches places the eyepiece at a comfortable position for seated viewing no matter how high the scope is pointed. With the legs at their shortest, damping time from a rap to the side of the tube was 2 to 2½ seconds. With the legs extended an extra foot or so, damping time was about 3 seconds. Placing a set of Celestron Vibration Suppression Pads under the tripod legs cut the damping time to between 1 and 1½ seconds.

The tube is clamped in a mounting ring that in turn fastens to the Gibraltar head with two hand-tightened bolts. (Setting up the Genesis requires no tools.) When switching from a heavy 35mm Panoptic or 20mm Nagler eyepiece to a lightweight eyepiece, it's best to rebalance the scope. This takes only a few seconds and is a matter of turning a handle to loosen the mounting ring's grip and then sliding the tube up or down within the ring.

I also checked out Tele Vue's new Air Chair seat, a sturdy, well-padded drummer stool with a handy pneumatic height adjustment. The 5-inch range in seat height from 20 inches to 25 inches complements the range the eyepiece swings through in *altitude.* Whether you are looking at the horizon or at the zenith, you can remain comfortably seated without the need to stretch or crouch, a convenience that adds immeasurably to the pleasure of using this telescope.

The Computer Option

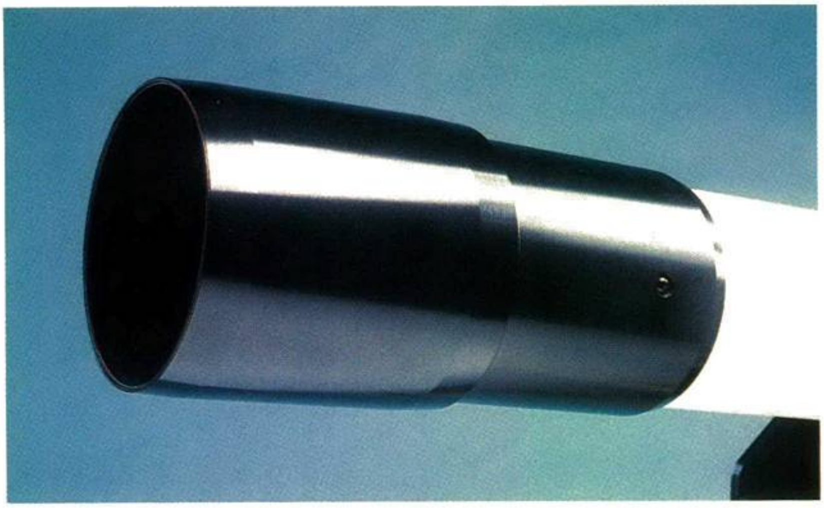
To add to the Genesis system, Tele Vue has just introduced its Sky Tour computer. I tested an early sample of the Sky Tour, a unit with version 1.00 of the software. Similar in function to Celestron's AstroMaster and JMI's NGC-Max computers, Sky Tour uses four buttons to control all functions and comes installed with a database of 2,000 of the finest deep-sky objects in a computerized list compiled by Tom Lorenzin, author of the book *1000+: The Amateur Astronomer's Field Guide to Deep Sky Observing*.

Calibrating the Sky Tour is simple. You first level the scope by lining up two notches scribed on the Gibraltar mount. You then aim the telescope at two known stars you select from a list of 31 bright stars. The computer is then ready to guide you to any of the objects in its database. In the Guide mode, a display of the position of both axes counts down to zero as you manually swing the telescope to the object.

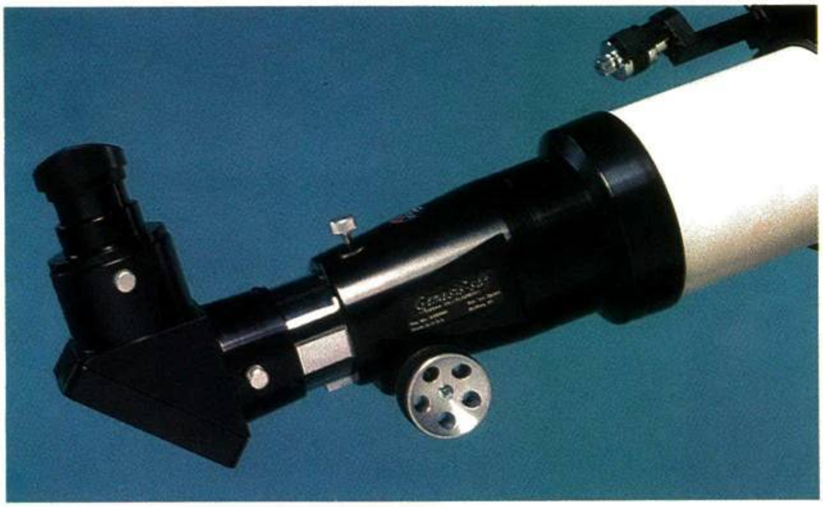
You can select targets from several catalogs of objects: from Messier, NGC and IC objects, stars, or planets, or from 181 of what Lorenzin calls "non-stellar objects," a fascinating selection of oddball galaxies, clusters, nebulae, and asterisms not found in the other catalogs. (Inexplicably, M24 and M25 were missing from the Messier list but appeared on other lists under other catalog numbers.) For all these targets, the computer's scrolling display provides the object's right ascension and declination coordinates, magnitude, size, and constellation, as well as a brief, plain-English description of the object. Sky Tour also allows you to enter the coordinates of up to 25 of your own objects, a new comet for example.

Sky Tour can also simply read out the right ascension and declination of where you are currently pointed. An Identify mode guides you to whatever targets of interest lie within 12° or so of your current position. In this mode you can have Sky Tour guide you to all nearby objects or to only selected classes of targets, only globular clusters for example. However, you cannot narrow the search by size, magnitude, altitude, or other criteria.

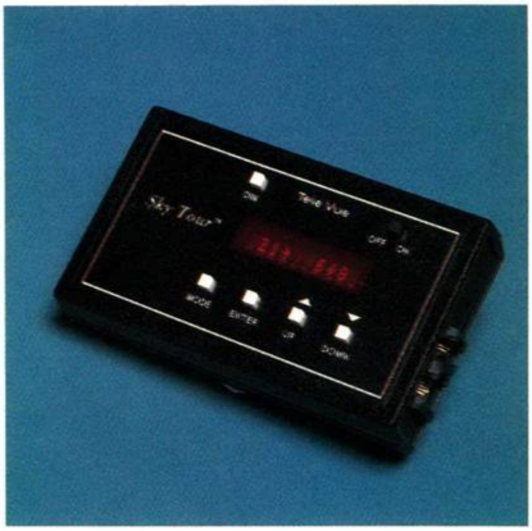
As with similar computers, Sky Tour takes a little getting used to. Buttons perform different functions depending on what mode you are in —



THE 6-INCH-LONG METAL DEWCAP slides forward from the metal lens cell with a velvet smoothness indicative of the fine machining found throughout Tele Vue's hardware. A metal lens cap screws over the lens cell when the dewcap is retracted.



THE RACK-AND-PINION FOCUSER operated smoothly with no backlash or image shift. The focuser accommodates 2-inch accessories and has a screw for tightening the tension. The focuser did not slip even with heavy cameras or eyepieces attached.



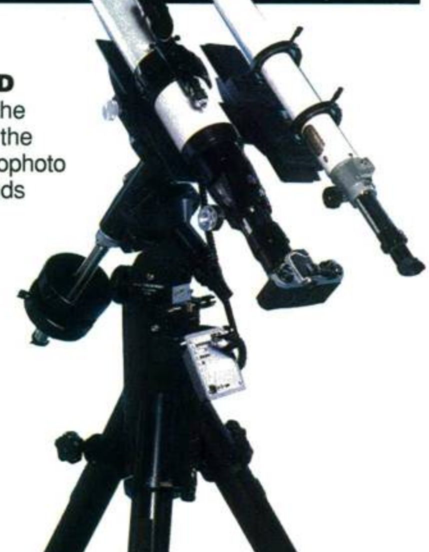
THE OPTIONAL SKY TOUR COMPUTER uses a minimal array of buttons to access a database of over 2,000 deep-sky objects. The Guide mode display shown here helps you locate objects by counting down to zero as you move the scope in the directions indicated.

ASTRONOMY: Alan Dyer

on my first night out I found it easy to get lost in the menus and commands. But after a couple of nights I found myself stepping through Sky Tour with ease. I especially liked its backlit buttons and handy palm-sized controller box. Since objects in the databases are listed strictly in numerical order, however, and not grouped by area of the sky, I found it best to prepare a list of targets before heading out for a night of computerized sky hopping.

Sky Tour's pointing accuracy was impressive. For every area of the sky, the computer located objects accurately enough to place them near the center of the field of a low-power 22mm eyepiece. This represented an average pointing error of less than half a degree, an excellent figure.

Of course, you don't need a computer to find your way around the sky. Tele Vue offers a finder called the Starbeam. When you look through this nifty device, you see a red dot projected against the naked-eye sky. The dot shows you exactly where the scope is pointed. With the aid of star charts, you can use the Starbeam to hop across the sky to targets the old-fashioned way. I found the Starbeam accurate enough to center objects in the field of high-power eyepieces. Its only drawback was its susceptibility to dew.



MATED WITH A GUIDESCOPE AND AN EQUATORIAL MOUNT such as the Celestron/Losmandy G11 shown at right, the Genesis serves as a superb deep-sky astrophoto scope. Test shots on 35mm film of starfields in Cygnus exhibited sharp star images corner to corner across a 4° field with little sign of vignetting.

The Sky Tour System

Tele Vue is currently promoting the Genesis, Gibraltar, Sky Tour, and other accessories as a complete observing system. All these components did, indeed, work well together. The Air Chair and mount form a comfortable, ergonomic combination. Sky Tour leads you to deep-sky objects while the Starbeam shows you where they are located to help you learn the sky.

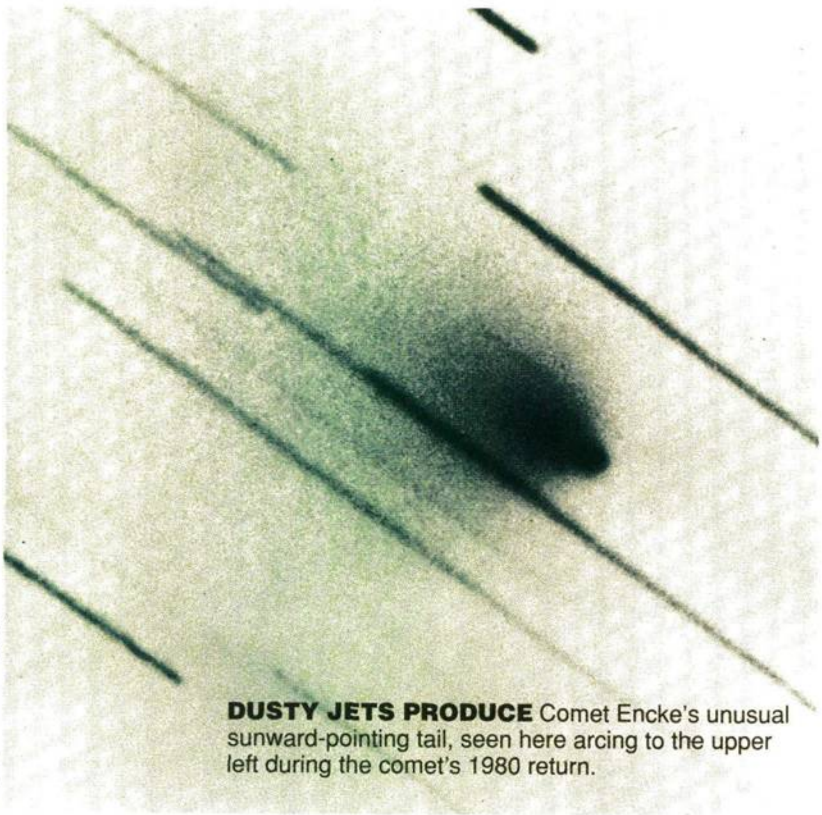
In all, I found the package well-engineered and friendly to use. With its 30-pound weight, the complete telescope was easy to carry into the backyard fully assembled so you could be observing in seconds. While an altazimuth mount such as the Gibraltar does not provide the tracking or astrophotography capability of an equatorial mount, it does provide ease of setup and simplicity of use.

If a portable, high-performance, and beautifully finished instrument is what you are seeking in an astronomical telescope, the Genesis SDF, with or without its functional accessories, is an excellent choice. □

COMET ENCKE RETURNS

Attention backyard observers: This month the evening sky plays host to a grand return of a grand old comet.

by Richard Talcott



DUSTY JETS PRODUCE Comet Encke's unusual sunward-pointing tail, seen here arcing to the upper left during the comet's 1980 return.

S. Djorgovski and H. Spinrad

Backyard comet observers have a veritable feast to look forward to in 1994. Three bright periodic comets return to the inner solar system this year: Borrelly, Encke, and Tempel 1. Although none will get bright enough to see with the naked eye, all will be easy targets in binoculars. First up: Comet Encke, the brightest and historically most important of the three.

You can start looking for Encke in early December 1993, when it glows softly at around 12th magnitude among the background stars of Pegasus and appears high in the evening sky. As it races down toward the Sun during the next two months, Encke grows continually brighter. By the beginning of January it should shine between 9th and 10th magnitude, and by the end of January it should be just below naked-eye visibility at 7th magnitude.

Part of the charm of following Comet Encke stems from its long and varied history. French observer Pierre Mechain first spotted the comet on the evening of January 17, 1786. But during that entire apparition it was seen only one other time — not enough for astronomers to calculate its orbit.

A Tough Nut to Crack

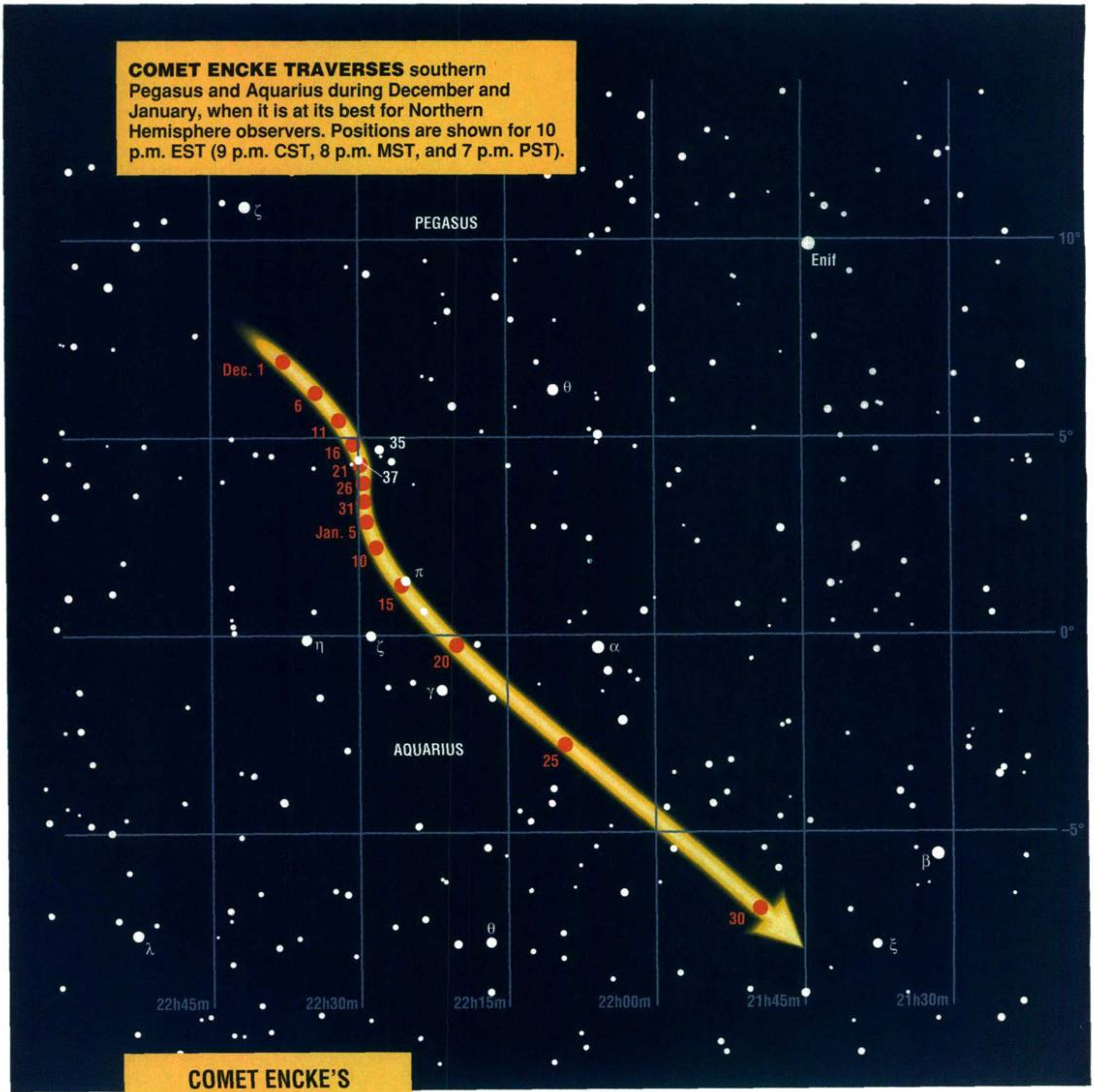
A frozen mudball, it remained out of sight for ten years, until Caroline Herschel rediscovered the comet on November 7, 1795. Despite three weeks of careful observations, astronomers still had no success computing an orbit that matched the comet's positions.

Ten more years rolled by before anyone saw the comet again. Then within a few hours on October 20, 1805, three comet hunters — Alexis Bouvard, Johann Huth, and Jean Louis Pons — independently sighted the comet. Observers measured the object's position for about a month, but alas, still that wasn't enough time to yield a reliable orbit.

The comet's next observed return didn't come until November 26, 1818, when the French astronomer Pons spotted it for the second time. For seven weeks, astronomers around the world carefully recorded the comet's position relative to the background stars. Johann Franz Encke of Germany soon recognized the problem: A parabolic orbit — the kind that describes a comet making its first trip into the Sun's vicinity — could not match the observed positions. When he tried to fit an elliptical orbit, the kind describing a periodic comet that regularly returns to the inner solar system, it worked. The best orbit he derived had the comet returning every 3.3 years.

Encke took the new orbit and calculated where this comet would have appeared in the past. He found that the comets of 1786, 1795, 1805, and 1818 were one and the same. It was seen at roughly ten-year intervals because the geometry of Earth, Sun, and comet repeated every third return, bringing very similar apparitions every three times 3.3 years. When the comet returned in 1822, just as Encke predicted, it officially became Comet Encke.

Astronomers soon learned that Comet Encke wasn't behaving the way it was supposed to. Back in the 17th century, English physicist Isaac Newton showed how objects orbiting under the influence of gravity should move. But Comet Encke



COMET ENCKE TRAVERSES southern Pegasus and Aquarius during December and January, when it is at its best for Northern Hemisphere observers. Positions are shown for 10 p.m. EST (9 p.m. CST, 8 p.m. MST, and 7 p.m. PST).

COMET ENCKE'S COORDINATES

Date	R.A. (2000)	Dec.
Dec. 1	22h37.7m	6°55'
Dec. 6	22h34.3m	6°07'
Dec. 11	22h32.0m	5°26'
Dec. 16	22h30.5m	4°50'
Dec. 21	22h29.8m	4°19'
Dec. 26	22h29.5m	3°50'
Dec. 31	22h29.4m	3°23'
Jan. 5	22h29.2m	2°52'
Jan. 10	22h28.3m	2°13'
Jan. 15	22h25.7m	1°15'
Jan. 20	22h20.2m	−0°15'
Jan. 25	22h09.2m	−2°47'
Jan. 30	21h49.5m	−6°56'

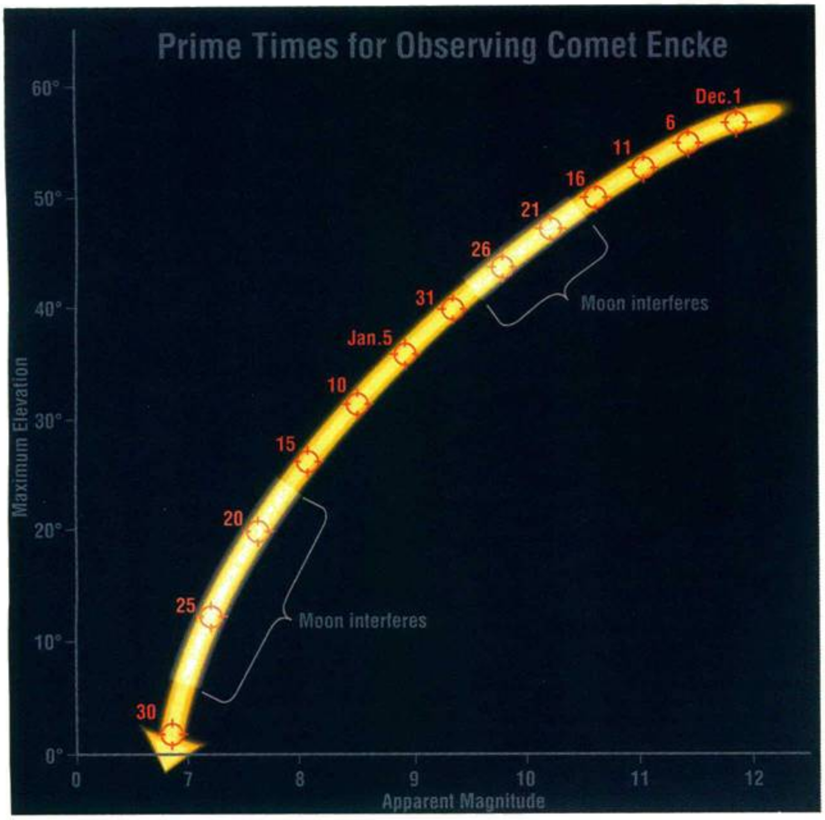
wasn't moving in quite the right way, even when the orbital calculations took into account the gravitational effects of the planets. Each time Comet Encke orbited the Sun, it returned to the same point in its orbit about three hours earlier than predicted. And while some periodic comets showed the same effect, others appeared to be slowing down.

What was going on? We now know that as the Sun warms a comet's nucleus, jets of dust and gas shoot out. The jets act like low-powered rocket thrusters. They either slow down or speed up the comet's orbital motion, depending on whether the nucleus rotates in the same or the opposite direction as the comet orbits.

These jets provide an observational extra you won't see with most other comets: Encke sometimes exhibits a tail that points toward the Sun. (Most comets, including Encke, have tails that point away from the Sun.) This tail usually appears while the comet is heading toward the Sun.

Right Place at the Right Time

Each time Comet Encke approaches the Sun, it does so on the part of its orbit that lies north of the



ENCKE GROWS BRIGHTER throughout December and January, but at the same time sinks closer to the horizon. This chart shows the comet's brightness and altitude at the end of evening twilight for an observer at 40° north latitude.

plane of Earth's orbit, the ecliptic. Then just about the time it reaches perihelion, its closest approach to the Sun, it slips south of the ecliptic plane and remains there as it heads away from the Sun.

For Northern Hemisphere observers, this means Comet Encke is by far at its best in the months prior to perihelion. For those south of the equator, on the other hand, Encke is at its best after perihelion. Because it comes so close to the Sun at perihelion — passing within 0.33 astronomical unit, one-third the distance between the Sun and Earth and the second smallest perihelion distance of any short-period comet — Encke never strays more than about 20° from the Sun at its closest approach. That makes it nearly impossible to observe for the week or two around perihelion.

This year Encke reaches perihelion on February 9. For observers in the Northern Hemisphere, this yields a good apparition in the evening sky during December and January. If you live on the southern part of Earth's globe, you'll see Encke reasonably well before dawn in late February and March.

Observing Prospects

The first good opportunity to observe Encke comes in early December. On the 1st, the comet lies high in the south just as evening twilight comes to an end. You'll need the light-gathering power of a 3-inch or larger telescope to spot Encke, which should glow around 12th magnitude. Look for a faint, fuzzy patch of light lying about 4° south of the 3rd-magnitude star Zeta (ζ) Pegasi. Don't dawdle if you observe it on the 1st — the waning gibbous Moon rises shortly after twilight ends, brightening the sky to hinder your view later in the evening.

For the next two weeks, conditions improve dramatically. The Moon continues to wane until New Moon on December 13, giving you more dark time each evening to observe. And the comet brightens rapidly, by about one magnitude every 12 days. Encke heads southwest during this period but moves slowly enough that you'll have little problem following it from one night to the next.

The Moon returns to the evening sky around December 18, hampering your view of the nebulous comet for the next ten days. But you may want to try to view Encke on the 19th anyway, as it passes just 0.1° from the 5th-magnitude star 37 Pegasi.

By the end of December, Encke once more appears in a dark sky, considerably brighter than at midmonth and still quite high in the sky. At the end of twilight on New Year's Eve, it lies 40° above the southwestern horizon and should glow around magnitude 9.5, bright enough to observe with 10x50 binoculars or a 2-inch telescope. This is perhaps the best time to see Encke's sunward-pointing tail.

The first 15 days of the new year should provide the best views of the comet. It brightens to 8th magnitude and still possesses a good altitude at the end of twilight. On the 15th, Encke lies about 25° above the west-southwestern horizon. It is then less than 1° southeast of the 5th-magnitude star Pi (π) Aquarii, the northernmost star in the Water Jar asterism in the constellation Aquarius.

During the last half of January observing conditions deteriorate rapidly. Encke's motion relative to the background stars increases dramatically, pushing it closer to the Sun and the horizon with each passing day. And the waxing Moon returns to the evening sky with its unwelcome light around January 17. The only bright spot is that Encke itself grows brighter, reaching 7th magnitude during the last week of the month. The Moon takes a break for the last three days of January, but by then the comet is only a few degrees above the western horizon at the end of twilight. Your best bet on these days is to start looking for Encke before twilight fades completely.

During the first half of February, Encke lies too near the Sun for us to see it. After passing perihelion on February 9, it moves into the morning sky and becomes visible to Southern Hemisphere observers. From south of the equator, late February and mid-March are the best times to view the comet because the Moon is out of the morning sky. Encke then lies in Capricornus and appears between 10° and 20° above the east-southeastern horizon as morning twilight commences.

By the time March comes to a close, Encke will be fading from view. Although it will return in just 3.3 years, it won't be favorably placed then for Northern Hemisphere observers. We'll have to be patient, waiting until late 2000 before the comet puts in another good appearance. But if you take advantage of these crisp winter evenings, you'll have pleasant memories to tide you over. ☐

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Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

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Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

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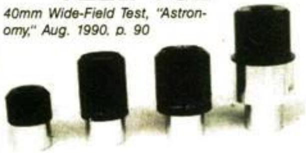
ASTROPHOTO OF THE MONTH

NGC 253 in Sculptor. 120 minute exposure by Andrew Peters using hypered 2415 film and a **LUMICON Coma Corrector** and **2'' LUMICON Easy-Guider** in a 20'' f/5 telescope.

"I'd Pick The TELE VUE™"

40mm Wide-Field Test, "Astronomy," Aug. 1990, p. 90



Genesis 4'' f/5 4 element fluorite .. $1595
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32mm Plossl, widest true field in 1¼''. $109
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The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16'' aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

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Specify telescope size: 6'', 8'', 10'', 11'', 14'', 16''

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Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	**H-Alpha**	**(MV)**
46, 48, 49mm	$59.00	$49.00
52, 55, 58, 62mm	$69.00	$59.00
67, 72, 77mm	$79.00	$69.00
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Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3'' & 2.1'' enhanced aluminum diagonal mirrors & 1¼'' star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

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90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼'' (1.32'' mirror) **$99.50**
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LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

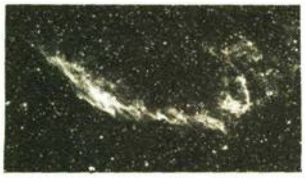
AMAZING OIII FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.



"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*

Rich Zepernick, Cresskill, NJ

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"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."*

Astronomy, Feb. 1991

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0.96'' LUMICON DEEP-SKY Filter threads into most 0.96'' eyepieces **$59.50**
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LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼''** .... **$99.50, 48mm** **$199.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines .... **1¼'' $99.50, 48mm $199.50**
Telephoto lens adapter for 2'' or 48mm filter. Select 46, 49, 52, 55, 58mm **$6.95**
Universal adapter for 1¼'' filters. Adapts the 1¼'' filters to any 1¼'' eyepiece **$16.00**
Universal adapter for 48mm or 2'' filters. Allows use of any 1¼'' eyepiece **$20.00**

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

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FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

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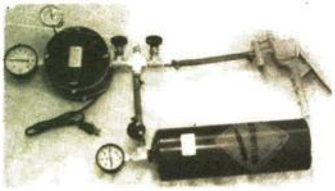

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

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Specify Camera and Telescope type.

U.S. Patent 4,448,500

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Full aperture. Installs in seconds. Specify 2'' or 1¼''.

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For Celestron-11, C-14, and the 10'' Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
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WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.
2. Cable release for long exposures .. **$9.95**

3. **LUMICON Digital Drive Corrector** . **$249**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 30Hz/90Hz variable output controls telescope drive. 60Hz digital reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Dec. reverse switch for Newtonians.

Declination motor (state telescope) ... **$109**
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HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
2415, Ultra-fine B&W, red sens.	36	**$10.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Ektar 1000 fast, fine grain	24	**$12.95**
Fuji HG400 fine grain color neg.	12	**$10.95**
3M 1000, fastest slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

THE BACKYARD ASTRONOMER

EXPLORE the GALAXIES of CANCER

You know Cancer for the stunning Beehive Cluster. But beyond the Beehive's stars lies a legion of faint galaxies. Let's take a field trip to fourteen of them.

BY DAVID HIGGINS

IF you've ventured out on a winter night about 9 p.m. you've probably seen the Beehive Cluster (M44). It's the large fuzzy glow in the constellation Cancer, lying high in the east and plainly visible to the naked eye on a clear, dark night. For centuries skywatchers used the nebulous light of this cluster to foretell weather: If it was not visible, the weather was changing for the worse. In 1609 Galileo was the first to see the object resolved into myriad stars; today, you can repeat this observation with an ordinary pair of binoculars. You'll see the cluster's 50 stars scattered over an area of 95', nearly three times the diameter of the Full Moon. Yes, the Beehive is one of the sky's most impressive sights.

Yet something greater lies behind the veil of stars in the Beehive Cluster. Through this veil we can look beyond to the depths of intergalactic space to see a smattering of faint galaxies, fourteen in all, that are faint and challenging objects — the brightest glows at magnitude 14.5 and spans less than one arcminute. Make no mistake — observing these galaxies is not for the faint of heart. But if you have access to a 10-inch or larger telescope, you may find it electrifying to examine them. And you have one thing going for you: The bright stars in the Beehive Cluster serve as clear guideposts that make locating the positions of the galaxies relatively easy.

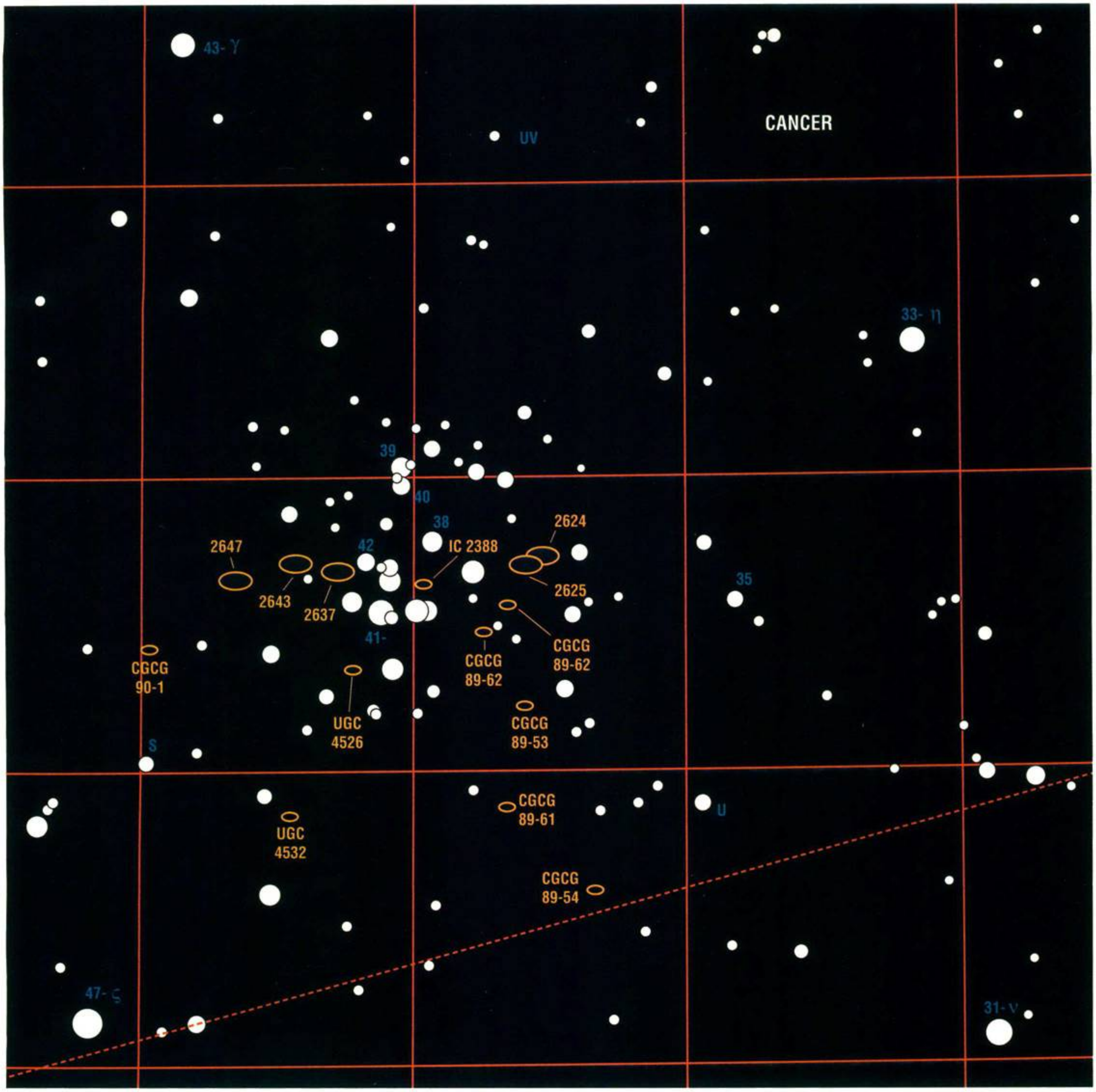
We'll begin our field trip to the galaxies of Cancer with the brightest galaxy, **NGC 2624**, which lies on the western edge of the Beehive. To explore the other galaxies systematically, we'll work our way eastward. The brightest, those listed in the *New General Catalogue*, are aligned in an east-west row that nearly bisects the star cluster. Fainter galaxies not belonging to the NGC but listed in other catalogs are scattered south of this main line. NGC 2624 glows dimly at magnitude 14.5 and measures 0.8' by 0.7'. In a 12-inch scope, it appears as an oval glow with a center slightly brighter than its edges. A 20-inch scope reveals a starlike core visible with direct vision. Southeast of NGC 2624, in the same low-power field, you'll find the fainter galaxy **NGC 2625**. This object spans 0.4' by 0.3' and glows at 15th magnitude, making it a challenge in anything less than a 12-inch scope. You'll probably need to use averted vision, glancing to the side of the field, to see it.

Six fainter galaxies lie south and east of the NGC 2624/5 pair, most listed in astronomer Fritz Zwicky's *Catalogue of Galaxies and Clusters of Galaxies*, which includes galaxies considerably fainter than those in the NGC. These six galaxies offer even more of a challenge than the NGC objects. **CGCG 89-56**, a tiny fuzzball not included in most observers guides, lies about 10' southeast of NGC 2625. This tiny object glows at magnitude 15.4 and requires a 16-inch scope to be seen. Moving your scope 20' south of this point brings you to **CGCG 89-53**, similarly difficult at magnitude 15.5. A 12-inch scope shows just a tiny spot of fuzz surrounding a starlike center.

Returning to the position of CGCG 89-56, aim your scope 10' southeast. This takes you to **CGCG 89-62**. At magnitude 15.6, this one is extremely challenging and probably not visible in anything less than a 16-inch scope. Now move your scope 45' south to **CGCG 89-61**, a virtual copy of its northern neighbor. A few arcminutes southwest of this object lies **CGCG 89-54**, a magnitude 15.2 galaxy that is somewhat easier to spot. The final faint galaxy in this area is IC 2388, which lies 20' east of **NGC 2625**, near the heart of the Beehive Cluster. Although this galaxy is listed at magnitude 16, its surface brightness is somewhat higher than that of the CGCG objects. In other words, the light from IC 2388 is concentrated in a small enough area to make it easier to spot. It should be routinely visible in a 16-inch scope.

Having viewed the challenging CGCG objects, you may wish to return to the east-west line of bright objects. You'll find **NGC 2637** a few arcminutes southeast of the bright star 42 Cancri, east of the Beehive's center. If the previous six galaxies proved elusive, you may have more luck with NGC 2637. Glowing at magnitude 15.4, this tiny object appears as a small spot of nebulous light with a reasonably high surface brightness. An evenly illuminated envelope of light surrounds the galaxy's bright center. Two objects listed in the *Uppsala General Catalogue of Galaxies* lie south of NGC 2637. Just 25' south of NGC 2637 you'll find **UGC 4526**, a magnitude 14.8 spiral that covers 1.4' by 0.4' and is sufficiently bright and elongated to appear like a galaxy in a large scope. About 30' southeast of this object you'll find **UGC 4532**, a 1.6' by 0.2' spindle of light that is an observing challenge on the best of nights.

Our field trip continues with the brighter galaxy **NGC 2643,** one of the east-west mainline objects that should be visible in a 10-inch scope. It lies east of NGC 2637 and just north of a 9th-magnitude star. The oval

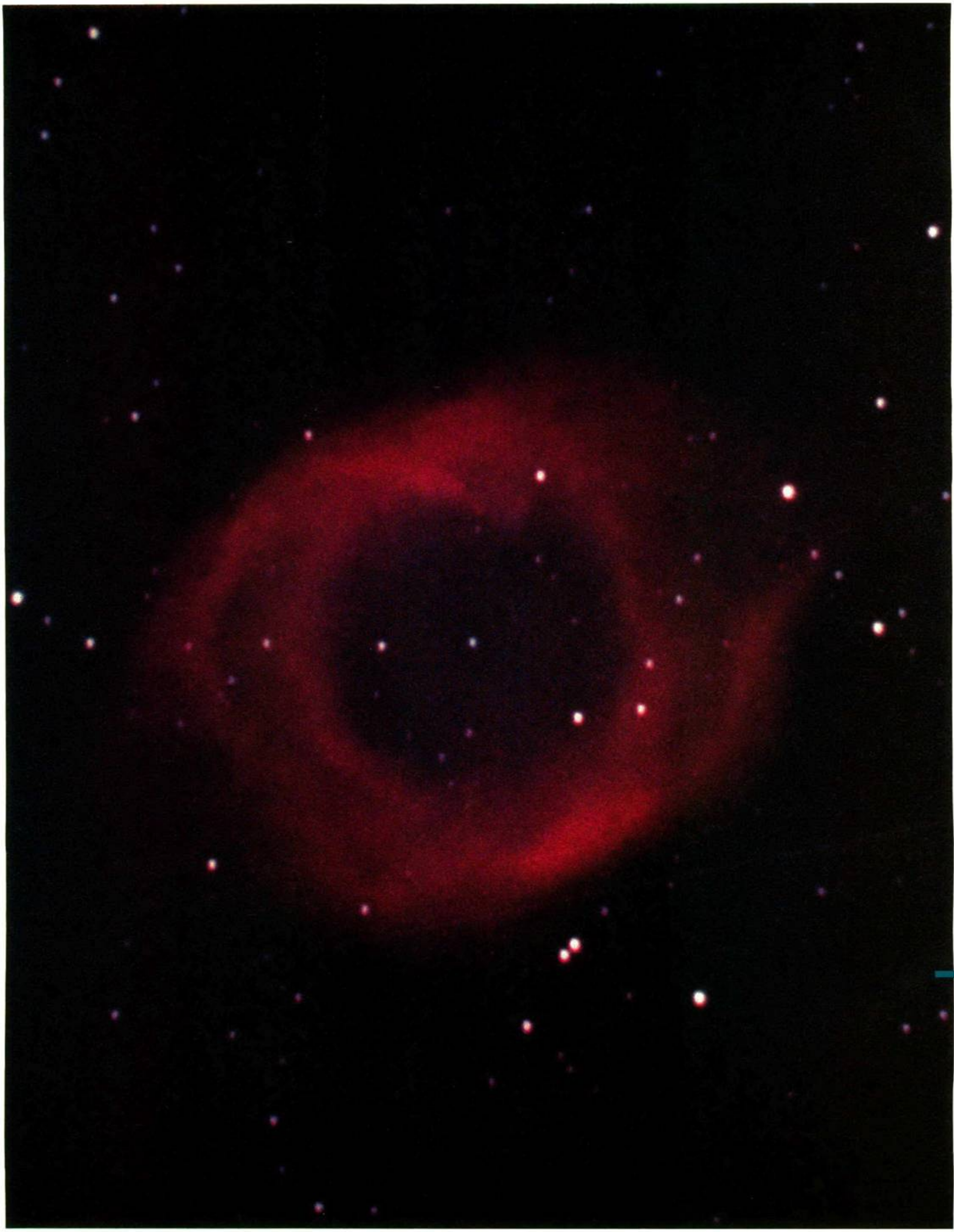


haze of NGC 2643 glows at magnitude 15.6, yet its surface brightness is high enough to make it appear brighter. The compact middle of this galaxy sits inside a round haze of very faint light. If you have a 10-inch or 12-inch scope, see if you can detect this object by using averted vision.

The final NGC galaxy is **NGC 2647**, located 15' east and slightly south of NGC 2643. At magnitude 15.2 this feeble patch of light will challenge your observing ability even with a 12-inch or 16-inch scope. The challenge here is the galaxy's low surface brightness. **NGC 2637**'s appearance in a 20-inch scope is that of a tiny nucleus surrounded by a faint haze that gradually fades into the sky background. NGC 2647 has a fainter neighbor 20' to the southeast, **CGCG 90-1**. This object glows dimly at magnitude 15.7 and shows no detail.

If on the first few attempts you don't succeed in locating all these galaxies, don't be discouraged. They are tough customers that require extremely transparent nights, equipment in tip-top shape, and your most patient, dark-adapted scrutiny. Keep at this distant group of galaxies lying behind the veil of Beehive stars because your trip will open your eyes to a whole new area of observing. Just pack up your equipment, prepare your maps, and enjoy. ☐

David Higgins is a frequent contributor to ASTRONOMY. His last article was "Tracking down the Helix" (October 1991).



Michael Stecker

THE MANY FACES OF PLANETARY NEBULAE

Use your small or medium-sized telescope to gaze at translucent clouds of gas ejected by dying stars.

by David Bruning

Winter offers deep-sky observers a marvelous selection of galaxies, star clusters, and emission nebulae. But lost in the glitz and glamour of the Pleiades, Orion Nebula, and Rosette Nebula are many planetary nebulae. Don't ignore these fine objects, thinking they're too small and faint. You don't need a large scope to see them: In fact, you can observe several with a 2.4-inch scope.

Despite their name, planetaries have absolutely nothing to do with planets. They got their name because early observers thought they resembled the disks of Uranus and Neptune. Instead planetaries mark the beginning of the end for stars like the Sun. As these stars finish their life cycle, they eject their outer layers. This ejection occurs more like a "poof!" than a "BANG!" as in a supernova explosion. The star then collapses to become a white dwarf, an earth-sized remnant of the star.

You can see some of the best of the over 1,000 planetaries that astronomers have catalogued during the winter months. Our tour starts with the brightest planetaries — ones you can see easily in small scopes.

An easy planetary to spot in small scopes or binoculars is the famous **Helix Nebula**, also known by its *New General Catalogue* number 7293. (Those of us who are grammatically impaired call it the Helix Nebula instead of the more proper Helical Nebula.) This is one of the closest planetaries, lying only 300 light-years away in the constellation Aquarius.

To find the Helix, start at Fomalhaut (Alpha Piscis Austrinus). Move your scope 11° northwest and point it a third of the way from 5th-magnitude Upsilon Aquarii to equally bright 47 Aquarii. Catch this planetary early in the evening before it sets. It lies close to the horizon, so be patient and wait for those moments when Earth's atmosphere is still and provides you with good "seeing." A murky or hazy horizon will prevent you from seeing it.

Being so near, the planetary appears bright at magnitude 7.3 and a whopping 12.8' across — about half the size of the Full Moon. However, the brightness is spread over the large size of the nebula, making the nebula hard to pick out from the sky background. So you need to look for it from a dark-sky site.

Small scopes show it as a circular patch that is obviously not starlike. A 6-inch scope reveals that the center is dark and contains a 13th-magnitude star. With a larger scope, you can see that the nebula is oblong and has a brighter band of nebulosity on the east side running north-south. You won't see the double loop of gas that is the trademark of this planetary. It appears only in photographs.

Another reasonably bright planetary is **NGC 7662** in Andromeda. Some astronomers call it the Blue Snowball because it appears bluish even in 2.4-inch scopes. You'll find the planetary 6.5° east of Omicron Andromedae and a half degree southwest of 6th-magnitude 13 Andromedae. Omicron is about 14° north of Beta Pegasi, which is the northwest star in the square of Pegasus.

The color of NGC 7662 is common in planetaries. Ultraviolet light coming from the stellar remnant excites

The Helix Nebula

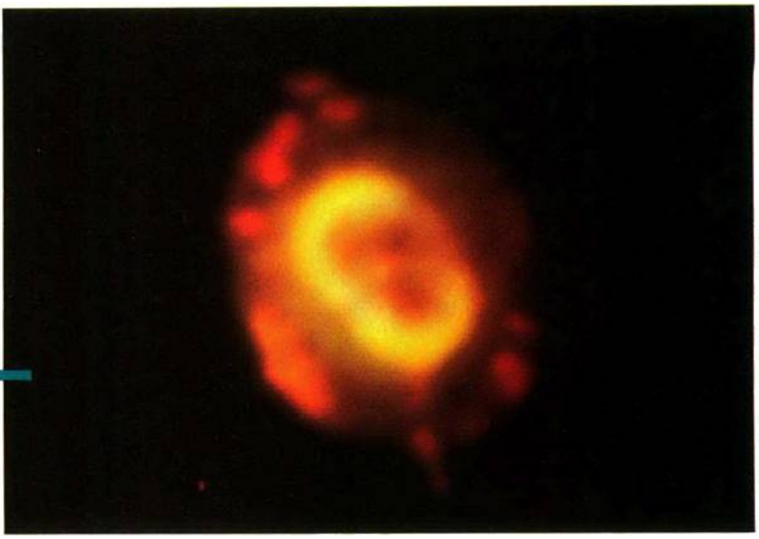
Mag. 7.3

Size >12.8'

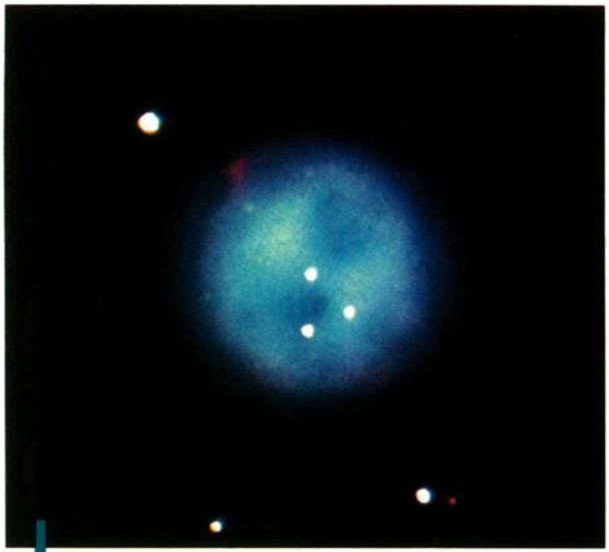
NGC 7662

Mag. 9.2

Size 20"



Bruce Balick, University of Washington/NOAO

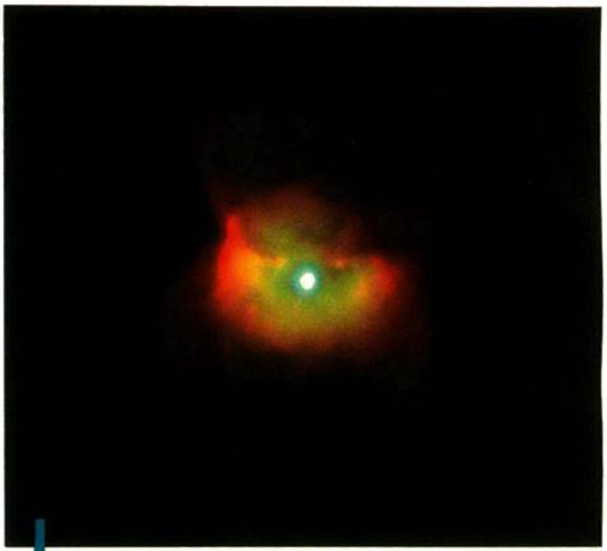


Jack Newton

The Owl Nebula

Mag. 12.0

Size 3.2'

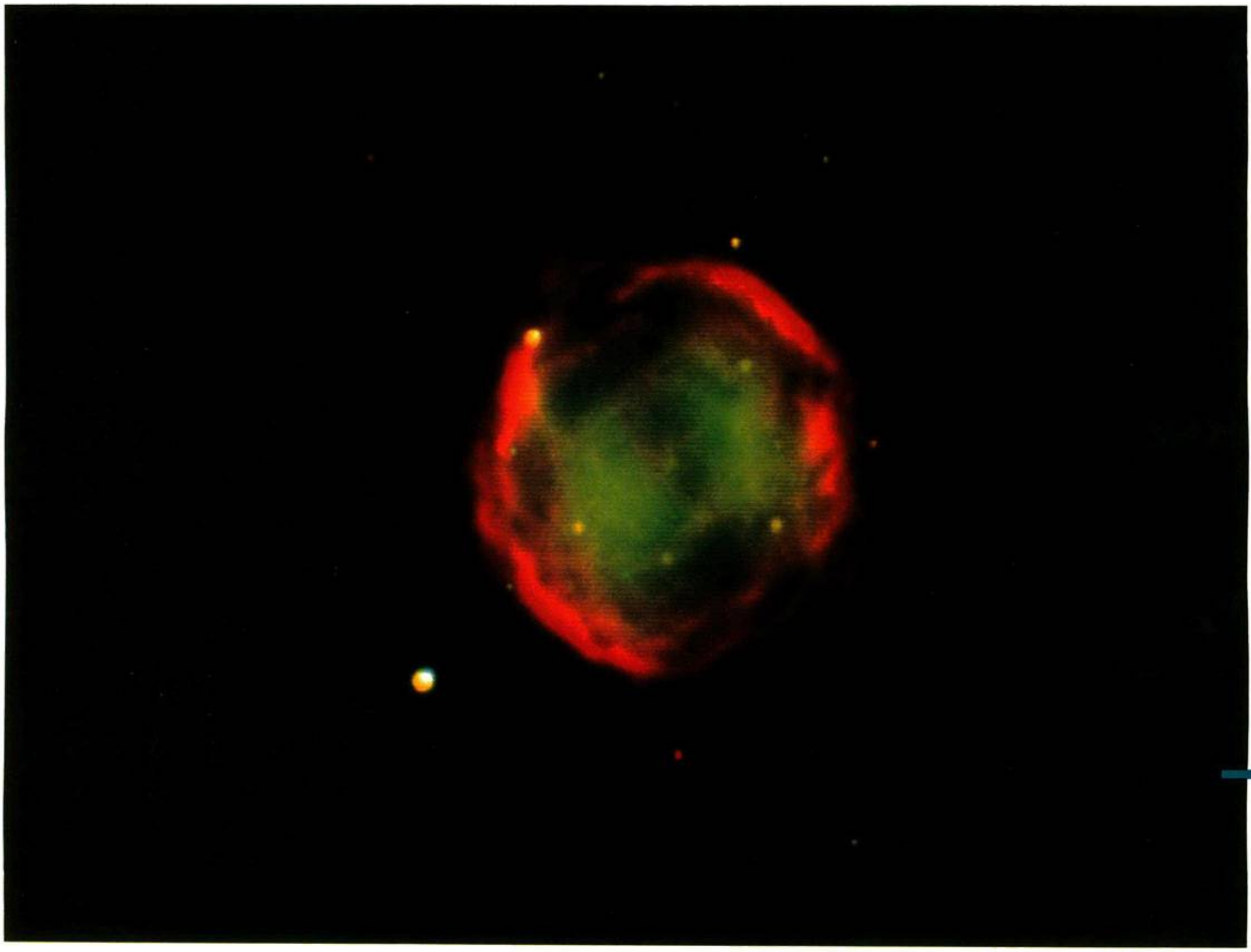


Bruce Balick, University of Washington/NOAO

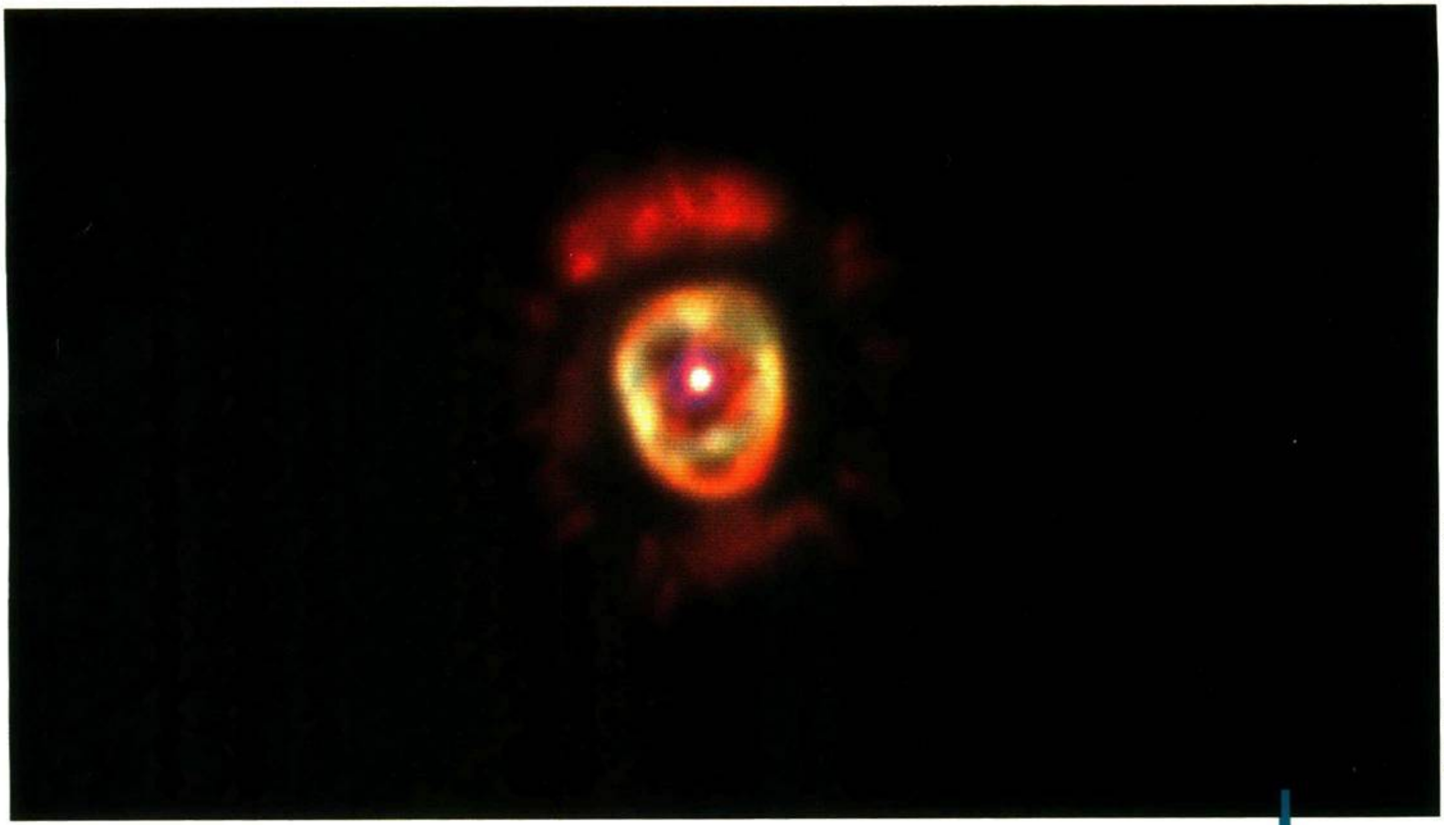
NGC 2346

Mag. 11.8

Size >55"



Bruce Balick, University of Washington/NOAO



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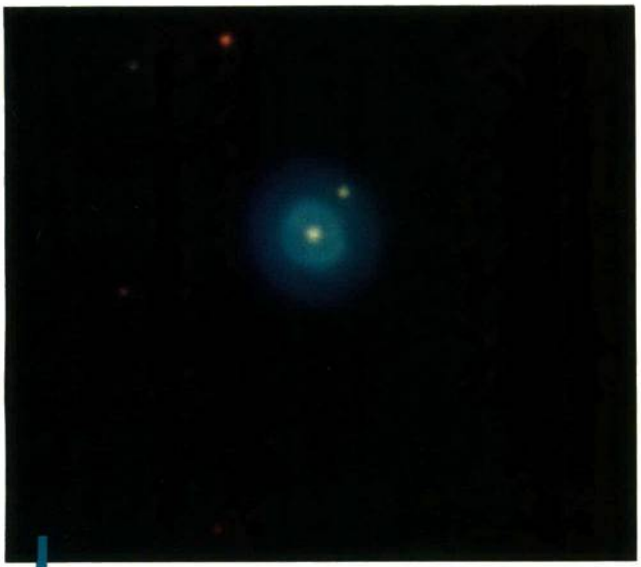
The Eskimo Nebula

Mag. 9.9

Size 13"



Rudy Schild, Center for Astrophysics

NGC 1535

Mag. 9.6

Size 18"

NGC 7139

Mag. 13

Size 78"

the nebula's gas, and the strong emission by oxygen in the gas produces the bluish or bluish green hue. The nebula lies faraway at 4,000 light-years, which makes the disk appear small — only 20" across. It shows a brightening on the northeast side in 6-inch scopes. Larger 10- and 12-inch telescopes reveal an out-of-round ring with a darker central region. The 13th-magnitude central star remains invisible because the nebulosity masks the star.

You'll find the next planetary in our tour in the constellation Eridanus the River. **NGC 1535** is a bright but small planetary nebula. Small scopes show it as nearly starlike, but 6-inchers reveal a bright circle inside a fragmented shell and a hint of the central star. A 10-inch scope lets you view the 12th-magnitude star easily. The nebula has a bluish green color and a well-defined core that is about 18" across and lies inside a larger halo.

To locate this planetary, start at the beginning of the westward crook in the River, marked by 3rd-magnitude Gamma Eridani. Go 4° east-northeast to NGC 1535.

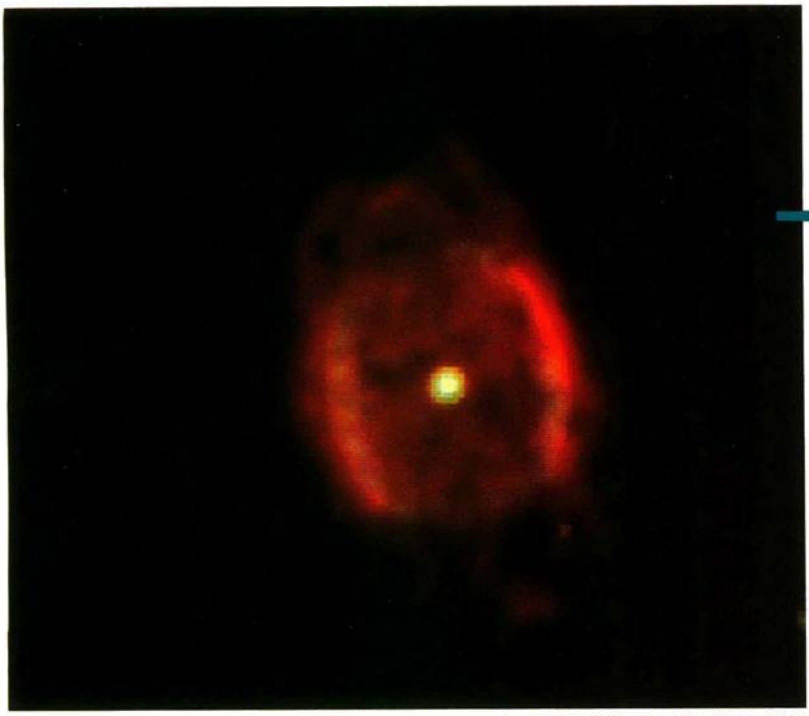
Some planetaries appear more like a disk — or even a face — than a ring. This is true especially of the **Eskimo Nebula** (NGC 2392) in Gemini the Twins. Because it lies 3,000 light-years away, the nebula appears somewhat small — 13" with a 44" halo. Although a 2.4-inch scope will uncover the 10th-magnitude planetary, you need a 6-inch scope and high power to see the central star and the nebula's bluish color. In a 10-inch scope, the disk appears patchy in brightness. You might also see a dark ring about halfway from the center to the edge. This marks vaguely the eyes and mouth in the

Bill Iburg

WINTER PLANETARY NEBULAE

Planetary	R.A. (2000.0)	Dec.	Mag.	Mag.*	Size
NGC 40	00h13.0m	+72°32'	10.7	11.6	>37"
M76	01h42.4m	+51°34'	12.2	17.0	65"/4.8'
NGC 1535	04h14.2m	–12°44'	9.6	12.2	18"/44"
NGC 2346	07h09.4m	–00°48'	11.8	11.2 var	>55"
NGC 2392	07h29.2m	+20°55'	9.9	10.5	13"/44"
M97	11h14.8m	+55°01'	12.0	15.9	3.2'
NGC 7139	21h45.9m	+63°39'	13	18.1	78"
NGC 7293	22h29.6m	–20°48'	7.3	13.5	>12.8'
NGC 7662	23h25.9m	+42°33'	9.2	13.2	20"/2.2'

Planetary: name of nebula; **R.A. and Dec.:** coordinates of nebula for epoch 2000.0; **Mag.:** photographic magnitude of the nebula; **Mag.*:** magnitude of the central star ("var" means it varies in brightness); **Size:** diameter of the nebula ("/" separates the sizes for the central core and halo; ">" means the entry gives the core size but the nebula has a larger halo).



Bruce Balick, University of Washington/NOAO

NGC 40

Mag. 10.7

Size >37'

The Little Dumbbell

Mag. 12.2

Size 65"

eskimo's face that you see more clearly in long-exposure photographs. The 10th-magnitude central star appears as the nose. The parka and details of the face remain invisible in backyard scopes.

Start at Delta Geminorum, the 2nd-magnitude star at the waist of the bottommost or southernmost twin. Go 2° east-southeast to a trio of stars, the brightest being 63 Geminorum at magnitude 5.2. Scan another half degree to the southeast to find the Eskimo.

The **Owl Nebula** (M97, NGC 3587) in Ursa Major is another of the funny faces that typify planetaries. Because it is relatively nearby at 1,300 light-years from our Sun, this nebula appears 3.2' in diameter. While you can see it in 2.4-inch scopes, the planetary remains indistinct even in 6-inch scopes. To see the two dark patches that make up the distinctive eyes of the Owl, you need at least an 8-inch scope and moderately high power (150x). The 16th-magnitude central star appears between the eyes. Few observers see color in the nebula.

Wait until at least midnight to look for this planetary. By then the Big Dipper will have risen high enough so you can see this gem. Trace a line from Beta Ursae Majoris to Gamma, the two stars that make up the bottom of the Dipper's bowl. The Owl Nebula lies a fourth of the way along this line and a degree south.

Not all planetaries appear as rings or disks. One that shows an irregular shape is **M76**, also known as the Little Dumbbell Nebula (NGC 650-1). It is the faintest object in the Messier catalog. Even so, you can see it in a 2.4-inch scope as an elongated patch that is 65" across and runs northeast-southwest. This planetary lies in the constellation Perseus at a distance of roughly 3,600 light-years. A 6-inch scope easily shows the nebula divided into two lobes that give the planetary its name. The southwest patch is slightly brighter. A 10-inch scope reveals a faint halo around the patches.

Although this planetary is in Perseus, you can find it more easily by starting from the star 51 Andromedae that marks the northern tip of V-shaped Andromeda. At magnitude 3.5, this star is visible even from suburban observing sites. Go about 2° north-northeast until you come to 4th-magnitude Phi Persei. Then point your scope a degree farther north, stopping at the 7th-magnitude star — directly west is M76.

The last planetary in our tour that you can see with small scopes is **NGC 40** in Cepheus. At magnitude 10.7, the nebula appears in 2.4-inch scopes, but you'll need at least a 3-inch scope and a dark sky to spot the 12th-magnitude central star. An 8-inch or 10-inch scope shows a dark region around the star. You need a 12-inch or larger scope to see any detail such as uneven brightness in the disk.

Begin at Gamma Cephei to find NGC 40. The nebula is 5.5° south-southeast of this star. Or you can start at Beta Cephei and go 3.5° northeast to 24 Cephei, a 5th-magnitude star. NGC 40 is due east about 2 hours in right ascension.

While you're exploring Cepheus, look for the barely perceptible **NGC 7139**. This planetary is a challenging object even in a 10-inch scope. It appears as just a faint patch although if you look away from the nebula to use the more sensitive rods of your averted vision, you may see a dark center. This planetary lies 3,900 light-years away and appears 86" by 70".

To see the next two nebulae, you need at least a 6-inch scope. **NGC 2346** is in Monoceros. Although it's fairly bright at magnitude 11.8, this planetary doesn't appear on many star charts. Yet it's easy to find because it lies only a half degree southwest from 4th-magnitude Delta Monocerotis. You can see this nebula easily in a 6-inch, but you'll need a 12-inch to view the squared-off shape of the planetary. The central star varies in brightness from magnitude 11.2 to 13.5 over about 16 days. You may have difficulty picking the star out from the nebulosity when the star is at its lowest light output, but high power shows it easily at other times.

To start your search for the nebula, first find Nu Cephei, a 4th-magnitude star between Alpha and Delta. The planetary is 2.5° north of Nu.

The planetary nebula phase lasts a scant 25,000 to 50,000 years out of the 5 to 15 billion years of the star's life. So planetaries provide us with a rare peek at stellar evolution. Once you start observing them, you'll be hooked on viewing the many different faces they present. And you'll never again be content with gazing at just galaxies and star clusters. □

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READER REPORTS

THE DISCOVERY OF SUPERNOVA 1993J

The massive star that exploded in galaxy M81 on March 28, 1993, was one of the brightest supernovae observed in recent years. It was discovered with a 10-inch reflector by Francisco García Diaz, an amateur astronomer living in Lugo, Spain. Throughout the spring and early summer of 1993 thousands of skywatchers viewed this supernova, designated 1993J.

The discovery was not an accident. On the contrary, simply ask any member of the M1 Supernova Search Group of the Madrid Astronomical Association. "Before Fran found the star in M81," says Jose Ripero, "we amassed 25,000 negative observations in 650 galaxies over a period of five years." After that amount of searching, how did the discoverer feel after finding a bona fide supernova? "I felt like a star being collapsed," relates Diaz. "I fell down from my stool and finished the observation on the floor."

Diaz recalls the progression of events that followed seeing a "suspect" star, one that appeared out of place. "I checked the Thompson-Bryan and Buil-Thouvenot atlases and as I expected, no star appeared on their charts where my star was shining forth. Could the star, at magnitude 14, be a variable?

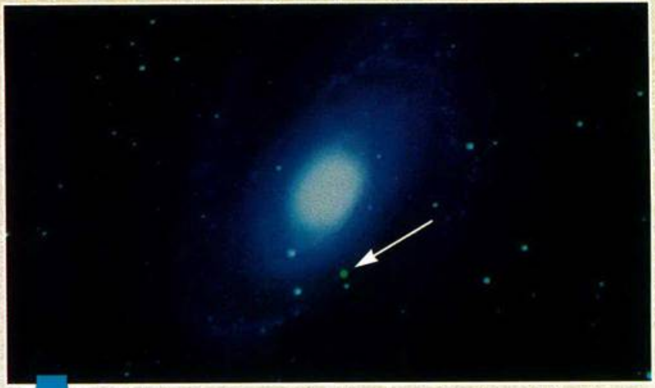
"I alerted other observers in our group. Another member of our club, Diego Rodriguez, soon called to tell me he had talked with astronomers at La Palma Observatory," Diaz continues. "It's a supernova!" The 25,000 hours had paid off for the dedicated group in Madrid.

Meteor Reports. A stream of meteor reports, mostly from Perseid shower observers, continues to reach us. "On August 11/12, I observed 75 meteors from 9:30 p.m. to 1:30 a.m.," says David Stine of Tulsa, Oklahoma. "The most unusual observation," he says, "was a double meteor at about 11:30 p.m. Two parallel streaks shot between Polaris and Cassiopeia and were separated by only 3° or so, with identical, smoky white trains. It was weird."

"Just as my kids were getting tired on the evening of August 11, suddenly an extremely bright meteor flashed overhead," says Laura Graham of Powhatan, Virginia. "It traversed a quarter of the sky before burning out and left a train visible for several seconds. We cheered and shouted wildly!"

Not all skywatchers stuck to the Perseids, however. On September 10, Manish Panjwani of Blacksburg, Virginia, was observing with binoculars along with a friend. At about 11:20 p.m. EDT "the most awesome fireball" Panjwani had seen in nine years of observing lit up the sky. "It originated in Draco and moved slowly along a path parallel to the horizon," he reports. "Its 'head' was bright yellow in color and seemed to be surrounded by a greenish halo. It probably had a magnitude of –7 or –8. The train glowed faintly for about 20 seconds before fading into the sky background."

The following night George W. Gliba of Greenbelt, Maryland, went observing from a dark site near Mathias, West Virginia. Gliba reported seeing several meteors from a "possible new radiant in Aries," near the bright star Gamma Arietis.



Supernova 1993J in the Galaxy M81

by Ronald E. Royer (18-inch f/7 reflector, taken on April 29, 1993)

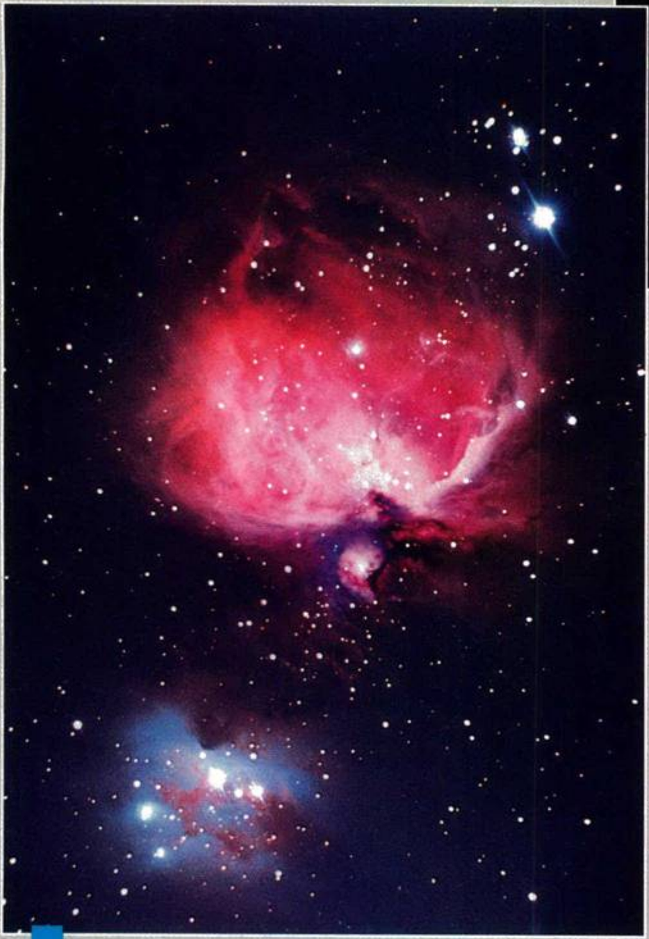
A Perseid Flashes Below Cassiopeia

by Ray Grover (50mm lens at f/1.4, Ektachrome film at 200 ISO, 60-second exposure on August 13, 1993)

Comet Shoemaker-Levy 9 and Jupiter Watch. This coming July the fragmented comet SL-9 will slam into Jupiter, producing a string of disturbances in the planet's cloudtops. (See Sky Almanac, p. 50, for complete details.) Observer Steve H. Lucas is providing material on the unique event to interested persons and is planning to assemble and distribute observations of the event. For more information, contact Lucas at 14400 Kolin Ave., Midlothian, IL 60445. CompuServe: 76620,1721.

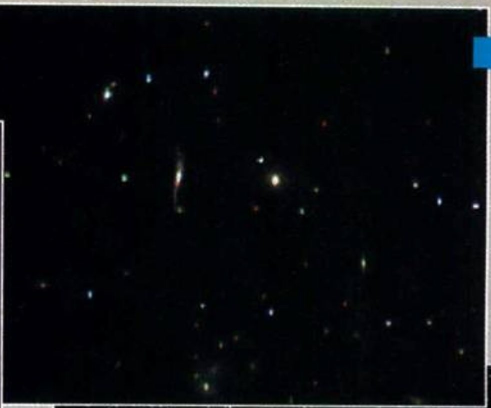
Total Lunar Eclipse. On June 4, 1993, a total eclipse of the Moon washed over western North America, Asia, and as far east as Africa. From Singapore, Norhaizat Latiff and a group of 400 skywatchers from the Astronomical Society of Singapore watched the eclipse. Latiff used a 3-inch scope. "The Full Moon rose over the treetops in penumbral shadow," says Latiff. "Just after mid-totality I managed to see all of the maria and the crater Tycho. It was a splendid sight. The umbra appeared light red to rusty red in color and fairly uniform in brightness." ☐

ASTRONOMY wants to hear about your observations of the sky. Please send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187. Be sure your name, address, and social security number accompany each submission.



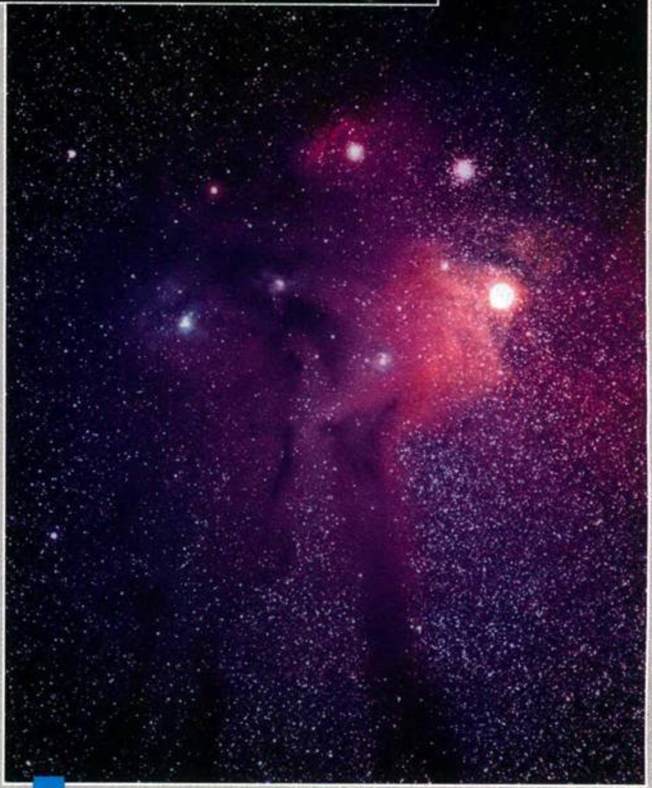
The Orion Nebula (M42)

by Chris Floyd
(10-inch f/4.5 reflector, hypersensitized Ektar 25 film, 100-minute exposure)



The Hercules Cluster of Galaxies

by Jack Newton
(25-inch f/5 reflector, SBIG ST-6 CCD camera)

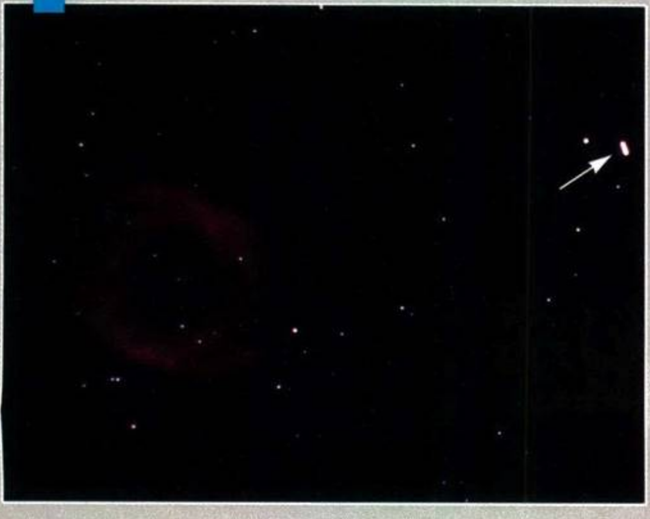


The Rho Ophiuchi Nebular Complex

by Michael Stecker and Bill Fletcher
(180mm lens at f/2.5, tricolor composite consisting of 42-minute [red], 80-minute [green], and 100-minute [blue] exposures)

The Helix Nebula and Minor Planet Vesta (arrowed)

by Don Munroe
(14-inch SCT at f/4.5, hypersensitized Fuji Super HG 400 film, 80-minute exposure on September 12, 1993)



CALL OF THE DEEP SKY

One of the greatest challenges to astrophotographers is capturing the subtle colors of a faint galaxy on film. To do this requires a long exposure with perfect guiding, flawless color processing, and exacting printing techniques. Jason Ware's photo of the Andromeda Galaxy (opposite page) wins this month's $100 "Best Astrophoto" award. It is a superb example of backyard astrophotography.

The Andromeda Galaxy (M31)

by Jason Ware
(6-inch apochromatic refractor, Fuji Super HG 400 film, composite of 75- and 90-minute exposures)

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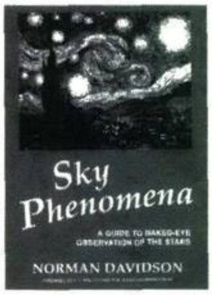

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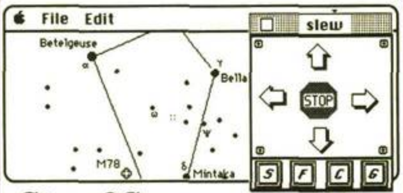

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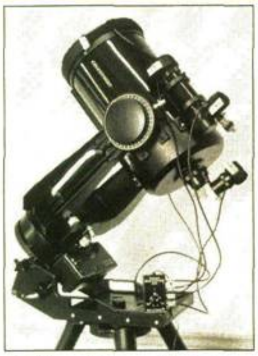

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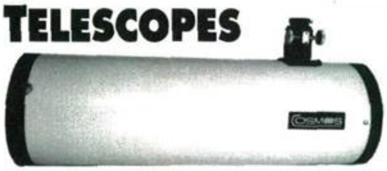

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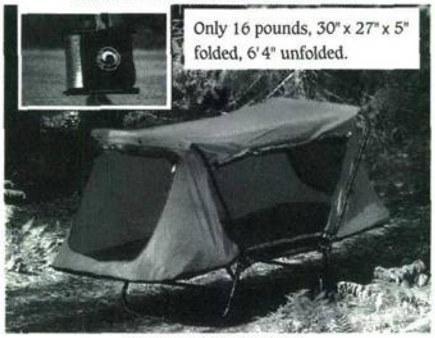

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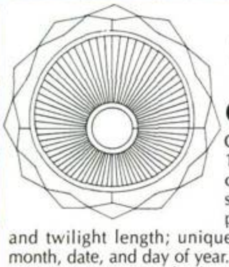

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Tour the Night Sky

Star-Hopping: Your Visa to Viewing the Universe

Robert A. Garfinkle, (Cambridge University Press, 1993), ISBN 0-521-41590-X, 306 pages, hardcover, $24.95.

Garfinkle takes you on 26 tours of celestial objects, including galaxies, gaseous nebulae, and star clusters. Each tour starts at a bright star and then hops along from telescope field to field until you end at the object of interest. Charts display the hops, and over 50 photos taken by noted amateur astrophotographers show you the objects you'll see. Introductory chapters describe the characteristics of stars, star clusters, nebulae, and galaxies and also provide some observing tips. The book concludes with a chapter describing a Messier marathon, an all-night observing session in March in which you attempt to view all 110 objects in Charles Messier's catalog. (Garfinkle's list includes the controversial identifications of NGC 5866 as M102 and NGC 4548 as M91, and the inclusion of NGC 205, the companion to M31, as M110.)

The Cambridge Eclipse Photography Guide

Jay M. Pasachoff and Michael A. Covington, with maps by Fred Espenak, (Cambridge University Press, 1993), ISBN 0-521-45651-7, 132 pages, softcover, $12.95.

May 10, 1994, marks the occurrence of an annular eclipse of the Sun that millions of people across the United States will view. Pasachoff and Covington describe the different types of eclipses and the circumstances that cause eclipses to occur, and show the paths of solar eclipses from 1994 through 1999. As the book's title suggests, they also tell you how to use your camera with or without a telescope to take pictures of the event, what film to use, and what exposures work best. They also include a chapter on how to videotape an eclipse.

The Vindication of the Big Bang

Barry Parker, (Plenum Press, 1993), ISBN 0-306-44469-0, 361 pages, hardcover, $24.95.

Big bang bashing became a popular sport around 1990. Parker explores this trend and the reasons some astronomers have stated the big bang is dead. He provides the scientific evidence for the big bang model in clear, nontechnical terms and concludes that the model is alive and well, although it does have some difficulties to face. He also discusses rival theories, citing their strong points and their pitfalls.

Light and Color in the Outdoors

Marcel Minnaert, (Springer-Verlag, 1993), ISBN 0-387-97935-2, 417 pages, hardcover, $44.50.

Most star watchers are also sky watchers, taking note of interesting plays of color and light such as rainbows, sun dogs, halos, and the green flash. Minnaert describes how and why these phenomena occur. He also discusses the properties of light and color in general and the perception of light by the eye. Astronomers will appreciate his discussion of magnitudes, night myopia, scintillation, and twilight. This reprinting of the 1974 edition includes some new discoveries about halos and 80 new photographs, 49 of which are in color. On nights with less-than-ideal astronomical viewing conditions, *Light and Color in the Outdoors* will transform your curses into shouts of wonderment.

The Box of Stars

Catherine Tennant, (Bullfinch Press, 1993), ISBN 0-8212-2038-1, 87 pages , 2 maps, and 32 color, punched cards, softcover book with boxed cards, $24.95.

This set of cards reproduces those of *Urania's Mirror*, first published around 1825. Each card has one or more classically drawn constellations on it, with punched holes of different sizes representing the stars. Holding the card at arm's length in a lighted room (or with a red-lit flashlight at night to preserve your night vision) demonstrates what the constellation looks like in the night sky. The two maps are not very accurate; you're better off with a planisphere or the star dome map from this magazine's Sky Almanac. Also the cards show many defunct constellations such as Tarandus the Reindeer, Custos Messium the Harvest-keeper, and Argo Navis the Ship. Consult some present-day maps so you'll know which ones in this set are of purely historical interest.

Children's Books

Mission to Deep Space

William E. Burrows, (W. H. Freeman and Company, 1993), ISBN 0-7167-6500-4, 80 pages, hardcover, $17.95.

Subtitled *Voyagers' Journey of Discovery*, this book describes the Voyager 1 and 2 spacecraft and their trips past the outer planets. Burrows discusses what we knew about each planet before the mission and how that picture changed after the flybys. Plenty of color pictures keep this book visually exciting for young readers.

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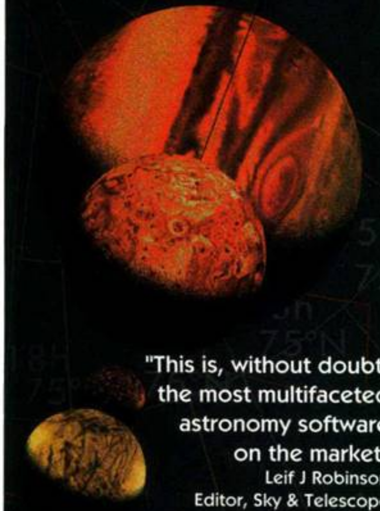

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ASTRONOMY BOOKS

Stars, Clusters and Galaxies: The Young Star Gazer's Guide to the Galaxy
John Gustafson, (Julian Messner, 1992), ISBN 0-671-72537-8, 64 pages, softcover, $6.95.

Here's a book that shows kids how to find their way around the night sky and locate some easy deep-sky objects by themselves. Gustafson provides many helpful tips for using star charts, measuring angular distances, seeing the effects of light pollution, and learning constellations. Young observers need only binoculars to find the nebulae, star clusters, and galaxies mentioned in the book.

Other Books Received

Mars
Hugh H. Kieffer, Bruce M. Jakosky, Conway W. Snyder, and Mildred S. Matthews, editors, (University of Arizona Press, 1993), 1,498 pages, acid-free paper, hardcover, $65.

A collection of 38 articles about the Red Planet's geology, atmosphere, and satellites. It includes an in-depth glossary and a guide to the nomenclature used to name regions on Mars.

100 Billion Suns
Rudolf Kippenhahn, (Princeton University Press, 1993), 268 pages, softcover, $16.95.

Kippenhahn's book on the life history of stars, first published in 1983 and written for a general audience, is now available in paperback with a new afterword.

Protostars and Planets III
Eugene H. Levy and Jonathon I. Lunine, editors, (University of Arizona Press, 1993), ISBN 0-8165-1334-1, 1,596 pages, acid-free paper, hardcover, $90.

An authoritative review of observational and theoretical evidence for how stars and planetary systems form.

Astronomical Photometry
Christiaan Sterken and Jean Manfroid, (Kluwer Academic Publishers, 1992), ISBN 0-7923-1776-9, 272 pages, acid-free paper, softcover, $44.

Sterken and Manfroid discuss everything you need to know to measure the brightnesses of stars. They describe filters, the effects of Earth's atmosphere on stellar brightnesses, and transformation from one filter system to another. Although they don't tell you how to build a photometer, Sterken and Manfroid detail the characteristics of the four main photometric detectors: the eye, photographic film, the photoelectric tube, and the CCD camera. □

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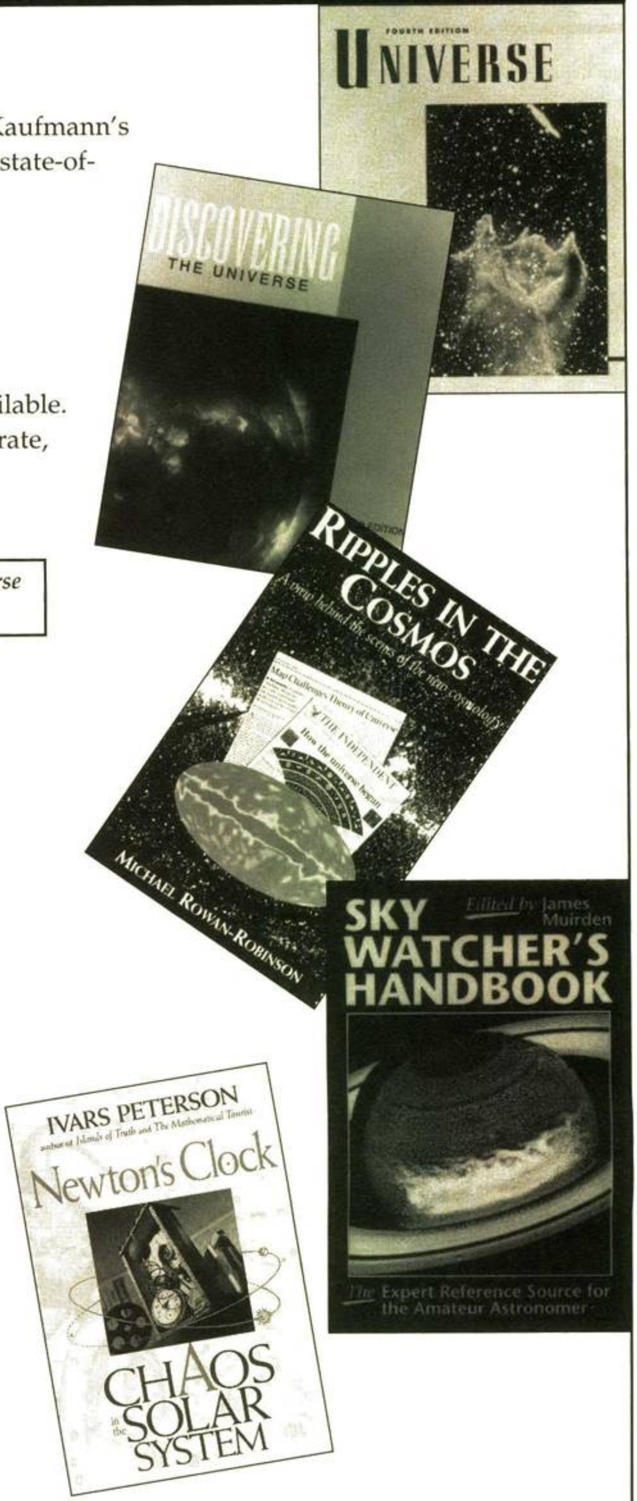
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Meade Instruments Corporation, 16542 Millikan Avenue, Irvine, CA 92714, (714) 756-2291, fax (714) 756-1450. $3,995. Packing and shipping: $215.

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Santa Barbara Instruments Group, 1482 East Valley Road, Suite #J601, Santa Barbara, CA 93108, (805) 969-1851, fax (805) 969-0299. ST-4 to ST-4X upgrade: $1,190; ST-4X to ST-5 upgrade: $500 (available spring 1994); ST-4X to ST-6 upgrade: approx. $2,000 (available late 1993).

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(continued on page 112)

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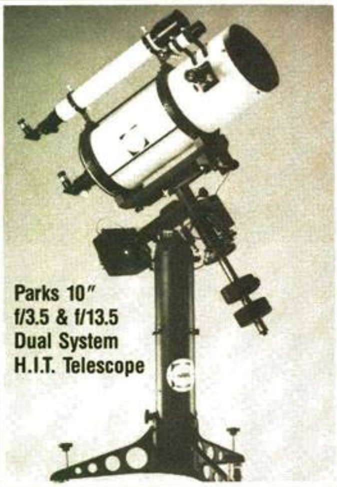

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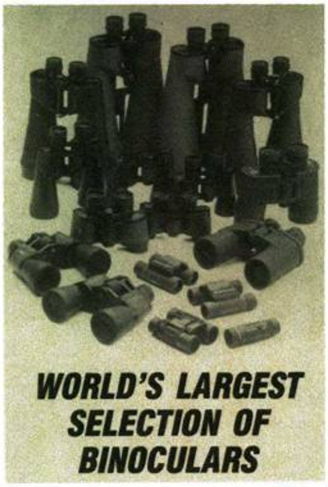

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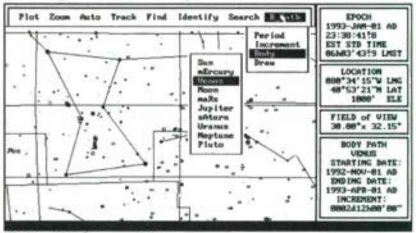

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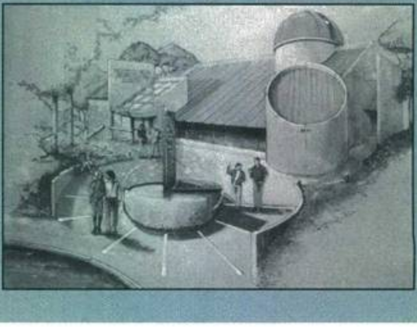

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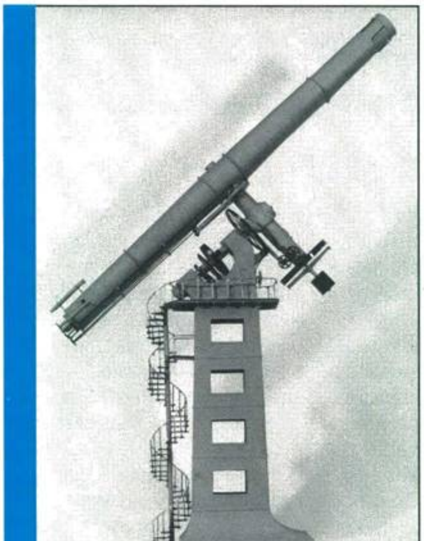

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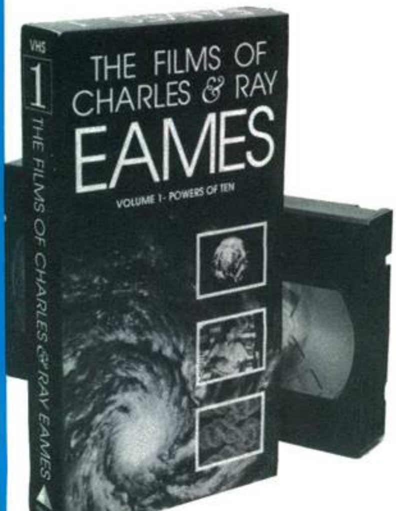
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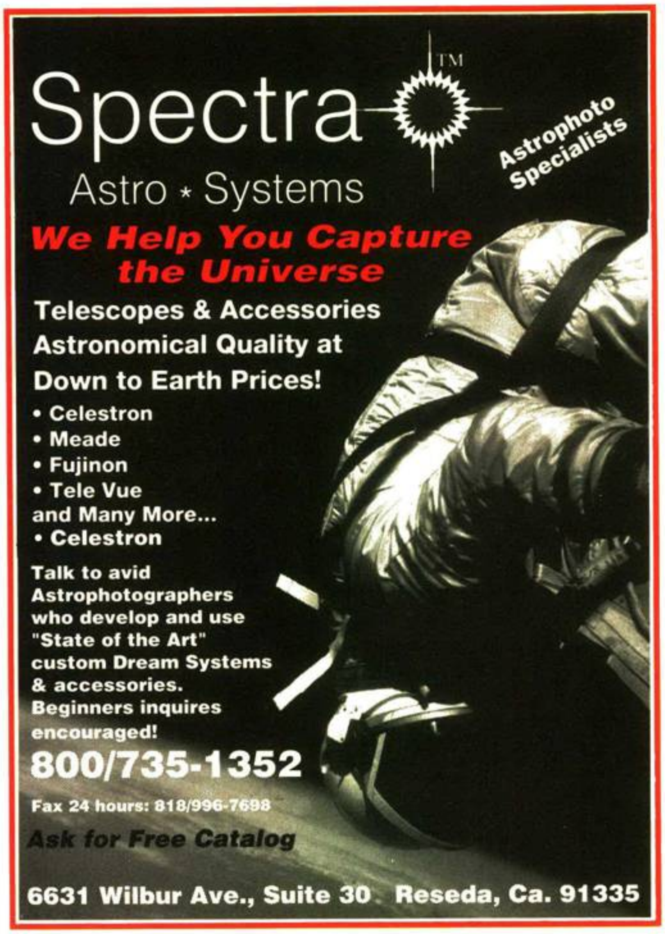

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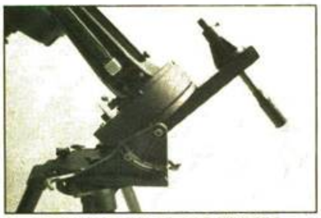

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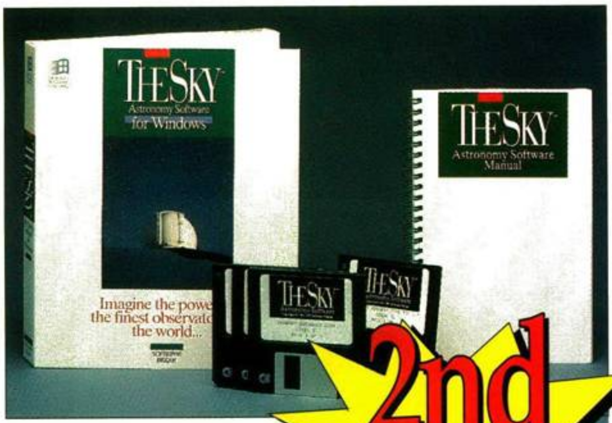

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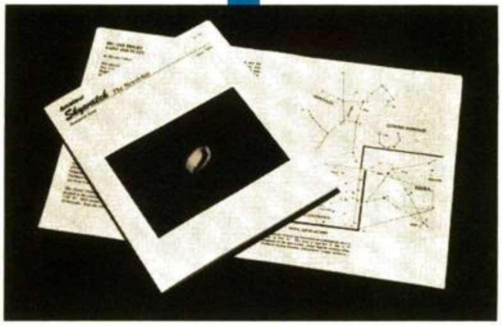
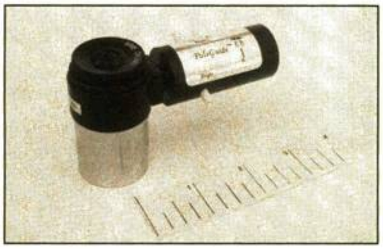


The Amateur Skywatch Association is a new organization dedicated to promoting amateur observing projects and observations. Annual membership includes the monthly *Amateur Skywatch* newsletter, which features articles about observing techniques and construction projects.

Amateur Skywatch Association, 535 North First Street, Suite E, El Cajon, CA 92021-6356. One-year membership: $16 ($20 outside North America, $24 for air mail). Club discounts available.



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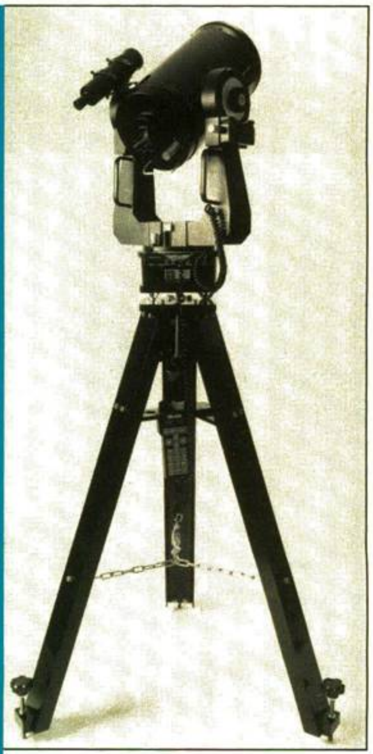
Rigel Systems, 26850 Basswood Avenue, Rancho Palos Verdes, CA 90274, (310) 375-4149. $39.95 plus $2 shipping.

Index Slides for Carousel Trays

The Data-Slide and Data-Dark slides are write-on slides for carousel slide trays that mark show segments or an individual slide using an index tab that extends above an image slide. Both versions accommodate standard adhesive-backed labels.

Data-Slide, 525 S. 4th Street E, Fort Atkinson, WI 53538, (414) 563-9590. Box of 50 of either type: $12.95; box of 100: $21.95. Add $3 shipping and handling.



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Star Dot Systems, P.O. Box 97, Bell Buckle, TN 37020, (615) 389-6761. $695.

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READINGS & CREDITS

Everything You Wanted to Know About the Big Bang (page 28)

A Brief History of Time, by Stephen W. Hawking, (Bantam Books, 1988). Written for the layperson, this best-seller weaves general relativity and quantum mechanics into the study of cosmology.

Fixing Hubble (page 36)

"How We'll Fix Hubble," by Greg Davidson, ASTRONOMY, February 1993. Describes the problem with Hubble's primary mirror and how the COSTAR instrument will improve blurry images.

Pluto and Charon (page 40)

"The Pluto-Charon System," by S. A. Stern, *Annual Reviews of Astronomy and Astrophysics*, vol. 30, 1992. Written for professionals, but interested amateurs will get a lot out of this review paper summarizing the latest Pluto knowledge.

1994 Sky Calandar (page 59)

Observer's Handbook 1994, edited by Roy Bishop, (Royal Astronomical Society of Canada, 136 Dupont Street, Toronto, Ontario, Canada M5R 1V2). A must-have guide to astronomical events.

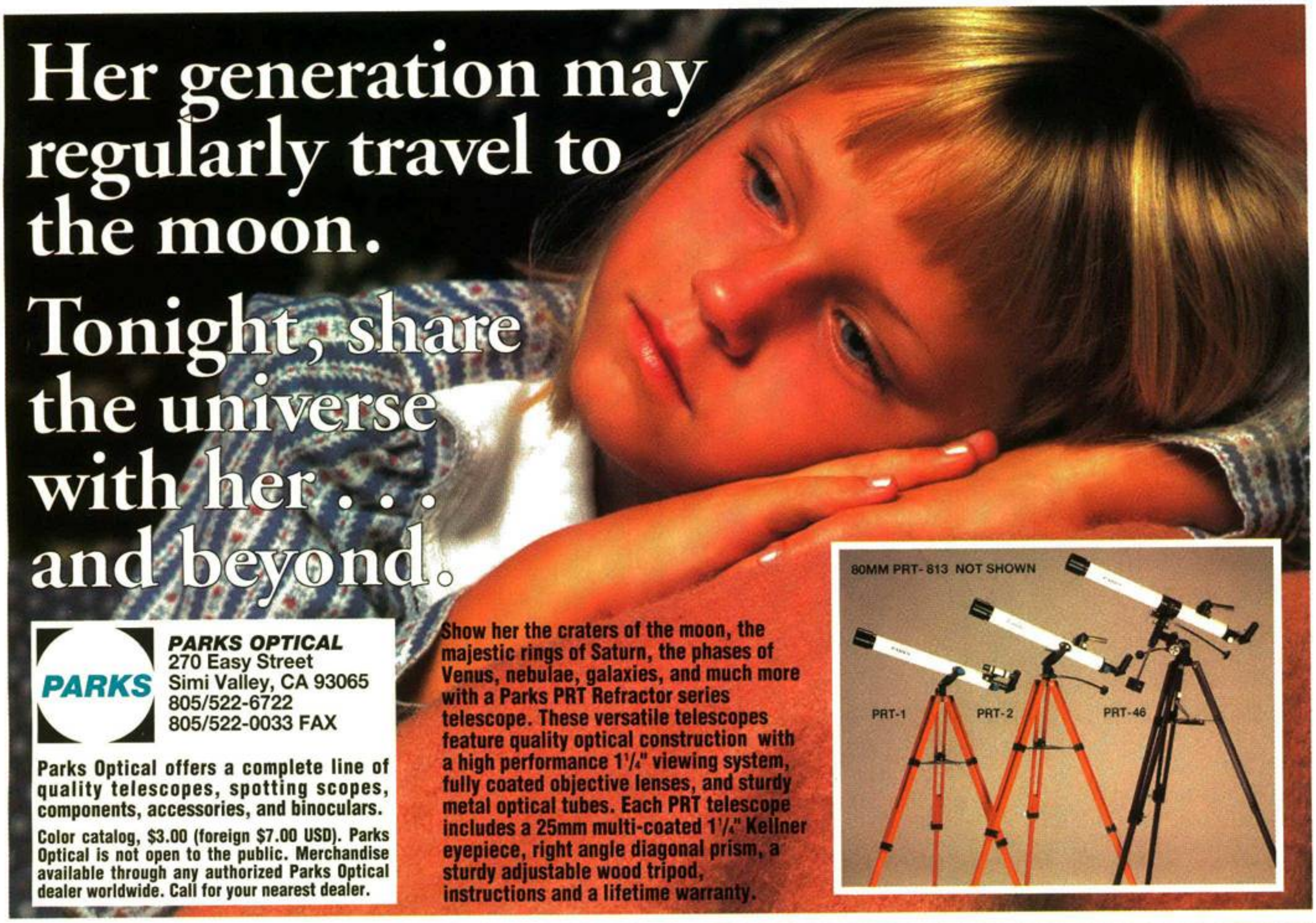
Explore the Galaxies of Cancer (page 92)

Observing Handbook and Catalogue of Deep-Sky Objects, by Christian B. Luginbuhl and Brian A. Skiff, (Cambridge University Press, 1990). Extensive observational notes outline hundreds of deep-sky objects, including the best in Cancer.

The Many Faces of Planetary Nebulae (page 94)

Beyond the Solar System, by David J. Eicher, (Kalmbach Books, 1992). Tells you how to find 100 deep-sky objects (including 10 planetary nebulae) and what you'll see through a telescope.

Cover: NASA; **p. 4:** Michael Carroll; **p. 18, left:** Hans-Water Rix; **inset:** Canada-France-Hawaii Telescope; **top right:** Francesco Parese, ESA/STScI and NASA; **p. 19:** H.A. Weaver and T.E. Smith, NASA/STScI; **p. 20, top right:** W. Dent/ Joint Astronomy Centre; **middle:** NASA; **bottom left:** Jordan Burkey, William Keel, and Gene Byrd/University of Alabama and Sethanne Howard/Universities Space Research Association; **p. 22, top left:** Allan Sandage/Carnegie Observatories; **top right:** Andrew Wilson/STScI; **bottom:** Hank Brandli; **p. 24, left:** David H. Levy; **right and bottom:** Alan Dyer; **pp. 28-35:** Thomas L. Hunt; **p. 35:** ©1984 Anglo-Australian Telescope; **p. 34:** Scott Kahler/ Ball Aerospace and Communications Group; **pp. 37-39:** NASA; **p. 40-41:** Pat Rawlings, NASA/SAIC; **p. 42, top:** U.S. Naval Observatory; **bottom:** Phil Kirchmeier, after NASA/JPL; **p. 43:** Phil Kirchmeier, after NASA/JPL; **p. 44, top:** STScI; **middle:** Marc Buie/Lowell Observatory; **p. 45, top:** Phil Kirchmeier, after Robert Marcialis/Pima Community College; **bottom:** Marc Buie/Lowell Observatory; **p. 46, top:** Pat Rawlings, NASA/ SAIC; **bottom:** Phil Kirchmeier, after NASA/JPL; **p. 47, both:** Phil Kirchmeier, after NASA/JPL; **p. 52:** Charles F. Capen; **p. 53:** Gert Kroner; **p. 55:** Keith Ward; **p. 56:** Yerkes Observatory; **p. 57:** Jane Luu/University of California at Berkeley; **p. 59:** Dewey Vanderhoff, Jan. 4, 1992 sunset annular eclipse; **60-73:** illustrations by Thomas L. Hunt and Phil Kirchmeier; **p. 60:** M35 by Sheldon Faworski, f/5 refractor, 20 minutes, Fuji 100 pushed to ISO 800; **p. 62:** Crescent Moon by Brian Tkachyk, 8-inch SCT, 1 second, Kodachrome 64; **p. 63:** Jupiter by Jean Dragesco, taken from Pic-du-Midi, France; **p. 64:** May 30, 1984 annular eclipse by Dewey Vanderhoff; **p. 66:** Comet Shoemaker-Levy 9 by James Scotti; **p. 69:** Venus by Edwin Faughn; **p. 70:** July 11, 1991 solar eclipse by Jeff Schroeder; 4-inch f/15 refractor, 1/30-second, Kodachrome 64; **p. 71:** Mars by D.W. Lyon, Sept. 25, 1988, 8-inch SCT at f/160; **pp. 76-79:** sketches by Lee T. Macdonald, artwork by Thomas L. Hunt; **pp. 82-86:** equipment photos by Darla Evans; **p. 86:** starfield by Alan Dyer, Genesis 4-inch f/5.4, 20 minutes, Scotchchrome 400 pushed to ISO 1600; **p. 87:** S. Djorgovsky and H. Spinrad; **pp. 88-89:** Steven G. Davis; **p. 93:** Thomas L. Hunt; **p. 94:** Michael Stecker; **pp. 95-96:** Bruce Balick; **p. 97, left:** Jack Newton; **right:** Rudy Schild; **p. 98:** Bill Iburg, 14-inch SCT, f/5.5, cold camera, Ektachrome 400, 40-minute exposure; **p. 99:** Bruce Balick; **p. 97, top:** Ronald E. Royer, 18-inch f/7 reflector, taken on April 29, 1993; **bottom:** Ray Grover, 50mm lens at f/1.4, Ektachrome at 200 ISO, 60-second exposure on August 13, 1993; **p. 98, top left:** Chris Floyd, 10-inch f/4.5 reflector, hypersensitized Ektar 25, 100-minute exposure; **bottom left:** Don Munroe, 14-inch SCT at f/4.5, hypersensitized Fuji Super HG 400, 80-minute exposure on September 12, 1993; **top right:** Michael Stecker and Bill Fletcher, 180mm lens at f/2.5, tricolor composite: 42-minute (red), 80-minute (green), and 100-minute (blue) exposures; **bottom right:** Jack Newton, 25-inch f/5 reflector, SBIG ST-6 CCD camera; **p. 99:** Jason Ware, 6-inch apochromatic refractor, Fuji Super HG 400, composite of 75- and 90-minute exposures; **p. 130:** Darla Evans; **p. 130:** Luke Dodd. ☐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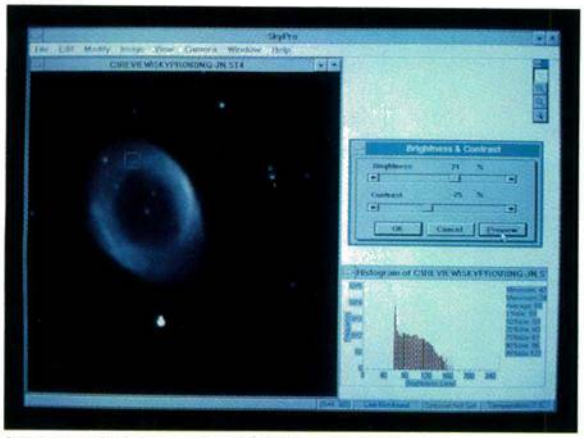

ASTRONOMY: Darla Evans; Ring Nebula image by Jack Newton

SkyPro (version 1.0)

Software Bisque, 912 Twelfth Street, Golden, CO 80401, (800) 843-7599 or (303) 278-4478. Price: $199. Minimum requirements: 80286-based computer, hard drive with 600 KB of free space, and Windows 3.1.

SkyPro is an image-processing program and CCD camera controller wrapped into one. If you have a SpectraSource Lynxx or Santa Barbara Instrument Group ST-6, SkyPro will set up your camera, take an image, and let you process the image all from one program. But you don't need a CCD camera to take advantage of this program's ability to enhance images. It will also let you input ST-4, GIF, TIFF, and BMP images taken by others.

You can adjust brightness and contrast, perform histogram brightening, or develop a customized brightness function to enhance an image. Filters allow you to sharpen, smooth, and apply an unsharp mask, or you can design your own filter. SkyPro also includes flip, flop, rotate, and shift functions to help you orient your images.

SkyPro has three features that make using this program a joy. Like more expensive image-processing programs, it has an undo function. You don't have to make copies of your image when you try a filter. If you don't like the result of the unsharp mask, just hit UNDO to restore the image. The brightness and contrast controls have a preview capability. SkyPro always gives you a chance to see what a procedure will do to your image before you make the change permanent.

The second is a "flash" command. It alternately displays two images in the same window. This is useful for variable star studies, nova and supernova searches, asteroid hunts, and planetary studies. You can select the blink rate for different applications. Also, because SkyPro can have a number of images open at the same time, you don't have to load the two images into separate buffers. You can choose the images from the FLASH menu.

The third simplifies compositing a tricolor image from three images taken through red, green, and blue filters. Tricolor imaging isn't supported by all image-processing programs so that feature by itself is a plus. But what makes SkyPro stand out is the simple and efficient way it merges the image. Many programs require that you determine the amount each image must be shifted in order to register the three images. It often requires a lot of trial and error. SkyPro asks you to identify a star on each of the images and automatically shifts the images so the star lines up.

My only recommendation for improving this program is a minor one that concerns the histogram plot. I would like to adjust the minimum and maximum brightness values displayed in an image using a cursor within the histogram plot. SkyPro requires that you plot the histogram and then go into the transfer function window to adjust the values. Putting this feature into the histogram window would make it more functional.

SkyPro is a companion to Software Bisque's TheSky planetarium program. You can now plan your observing session using TheSky and then point your scope using the program's telescope controller. Then switching windows, you can pop into SkyPro to set up your CCD camera, take an exposure, and process the image. And then you can store this image as a file in the BMP format and display the image every time you click on the object in TheSky. You can also use SkyPro by itself.

I really liked using this program. Finding and using the filters and functions is easy. And I love the UNDO function and the simplicity of the tricolor image merging. Software Bisque has another winner with SkyPro. — *Dave Bruning*

NEW SOFTWARE

Fetch (version 1.2)

Aldus Corporation, 411 First Avenue South, Seattle, WA 98104-2871, (206) 628-2320. Price: $295. Minimum requirements: Macintosh computer, system 6.0.7 or 7.X, 4 MB of memory, and a hard drive.

If you have lots of images stored on your computer, you may occasionally misplace one by forgetting its name or which folder you put it in. Fetch will help you keep track of up to 250,000 images per catalog. You may also browse through "thumbnail" versions of each image or search through a database by photographer name, object name, or various key words to find the image you want. The program uses the JPEG compression scheme to save memory and Apple's Easy Open to support a wide variety of file formats, including PC graphics formats.

The COSMOS for OS/2 (version 3.0)

Mensys, P.O. Box 674, 2100 AR Heemstede, The Netherlands, (011) 31-23-470837. Price: $89.95. Minimum requirements: IBM PC- or PS-compatible computer and OS/2 version 2.X. Recommended: math coprocessor.

Astronomers who use OS/2-based computers now have their own multitasking, 32-bit version of a planetarium program. The COSMOS will display and print star charts and calculate the positions of the planets, comets, and asteroids. Stellar positions include corrections for precession so you can plot sky maps over a wide range of dates. A click of your mouse will identify objects and provide information about them. You can also view images of selected objects. Finding a star, constellation, or deep-sky object is as easy as selecting its name from a list.

DarkSky

The Arizona Database Project, Inc., 3131 East Thunderbird, Suite 8-130, Phoenix, AZ 85032. Price: $129.95, plus $5 shipping in U.S. and $8 foreign. Minimum requirements: IBM PC-compatible computer, Windows 3.1, VGA display, mouse, and a hard drive. Recommended: math coprocessor.

The producers of the Arizona Database and AZVUE, a text-based program to read and display the database, have developed a star-charting program called DarkSky. The software uses the Arizona Database (version 9.0) containing over 60,000 deep-sky objects and the Master Stellar Database with almost 259,000 stars. DarkSky will do most everything AZVUE will do and adds printed star charts and a graphical display. To prepare for an observing session, you can make an observing list and print star charts in any orientation to match your eyepiece view. After the session, you can store observing notes for any object. Drawing a box around an object on your screen will display information about the object. You can zoom in to see what a field will look like using your telescope and eyepieces.

Astronomical Formulas

MathSoft, Inc., 201 Broadway, Cambridge, MA 02139-1901, (617) 577-1017. Price: $99. Minimum requirements: IBM PC-compatible computer, hard drive with 2.4 MB of free space, and PC Mathcad 3.1.

Astronomical Formulas is a software version of a reference book that links to Mathsoft's Mathcad calculation software. It provides the formulas for analyzing the spherical geometry of the night sky, calculating the positions of planets, and determining the times of astronomical phenomena. This "electronic book" also provides values for the astronomical and physical constants needed in the formulas and contains definitions, explanations, and an index.

Contemporary Laboratory Experiences in Astronomy

Department of Physics, Gettysburg College, Gettysburg, PA 17325, (717) 337-6028, e-mail: clea@gettysburg. edu. Programs for IBM PC-compatible computers require Windows. Programs for Macintosh computers are available separately for System 6.X and 7.X.

Project CLEA offers four astronomy lab exercises for IBM PC-compatible computers and five for Macintoshes. These labs use simulated telescopes to view objects and record data that students then analyze. They include CLEA_JUP: finding the mass of Jupiter; CLEA_PHO: measuring the brightness of the Pleiades; CLEA_HUB: determining the redshifts of galaxies and the Hubble redshift law; and CLEA_MER: finding the rotation period of Mercury. The Macintosh exercises also include Energy Transfer in the Sun. Program developers expect to add four more exercises in the next year.

To obtain the exercises you can write to the address above or download the programs electronically. From Internet, type ftp io.cc.gettysburg.edu (or ftp 138.234.4.10). Log in as **anonymous** and use your Internet address as the password. Enter the directory containing the CLEA files by typing **cd /pub/clea_products/mac** or **cd /pub/clea_products/ pc**. Then type **bin** to transfer the binary files and **get {filename}**. When you finish, type **quit** or **bye**.

You can also receive the files from the CLEA Bulletin Board (a sub-board of the Gettysburg Gazette RBBS). Dial (717) 334-0736. The bulletin board supports up to 9600 baud (8 bits, no parity, 1 stop bit). At "FIRST NAME?" type **anonymous user clea**. Use the carriage return to skip through the bulletins until you get to the "MAIN Command?" prompt. Go to the CLEA sub-board by typing **J CLEA**. To access the files, type **F** and then **D {filename}** to download a file. Use **G** to end your session. ☐

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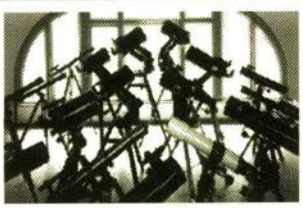

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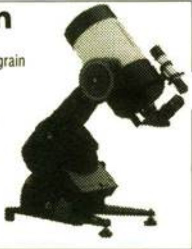

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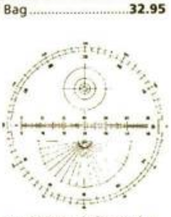

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MEETINGS & EVENTS

December 11
3rd Annual ASV Star-Be-Cue, near Melbourne, Australia. Sponsored by the Astronomical Society of Victoria. Contact Perry Vlahos, 103a Orrong Crescent, North Caulfield, Victoria, 3161 Australia, phone 61-03-527-8719.

January 11-15
183rd Meeting of the American Astronomical Society, Washington, D.C. Contact AAS Executive Office, 1630 Connecticut Avenue, NW Suite 200, Washington, DC 20009, (202) 328-2010.

February 7-13
Winter Star Party, Key West, Florida. Sponsored by the Southern Cross Astronomical Society, Inc. Contact Bob or Sharon Grant, 5401 SW 110 Avenue, Miami, FL 33165, (305) 595-8778.

March 14-18
25th Lunar and Planetary Science Conference, NASA Johnson Space Center, Houston, Texas. Sponsored by the Lunar and Planetary Institute and the NASA Johnson Space Center. Contact LeBecca Simmons, LPI Publications and Program Services Department, 3600 Bay Area Boulevard, Houston, TX 77058, (713) 486-2158.

April 16
International Astronomy Day. Contact your local astronomy club or planetarium for special activities.

April 30
48th Annual Convention of the North Central Region of the Astronomical League, Burlington, Iowa. Sponsored by the Southeastern Iowa Astronomy Club. Contact Dave or Marion Bachtell, 1901 South 10th Street, Burlington, IA 52601, (319) 753-1442.

May 5-11
1994 South Pacific Star Party, Sydney, Australia. Sponsored by the Astronomical Society of N.S.W. Inc. Contact Treasurer, Astronomical Society of N.S.W. Inc., P.O. Box 1093, Darlinghurst, N.S.W. 2010 Australia. ☐

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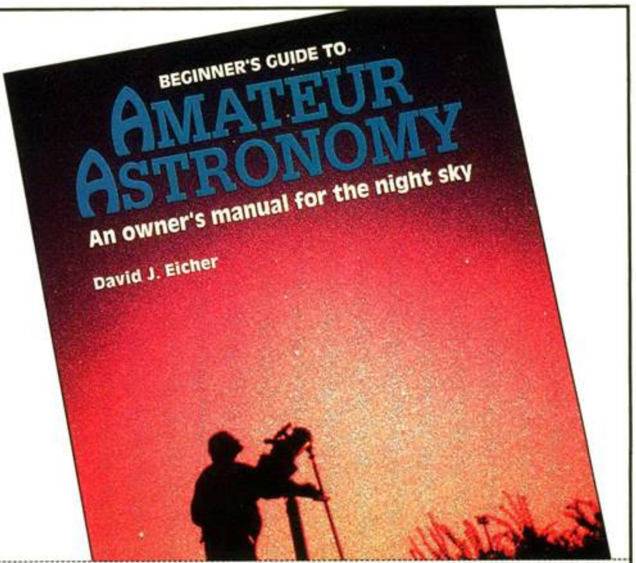

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Luke Dodd

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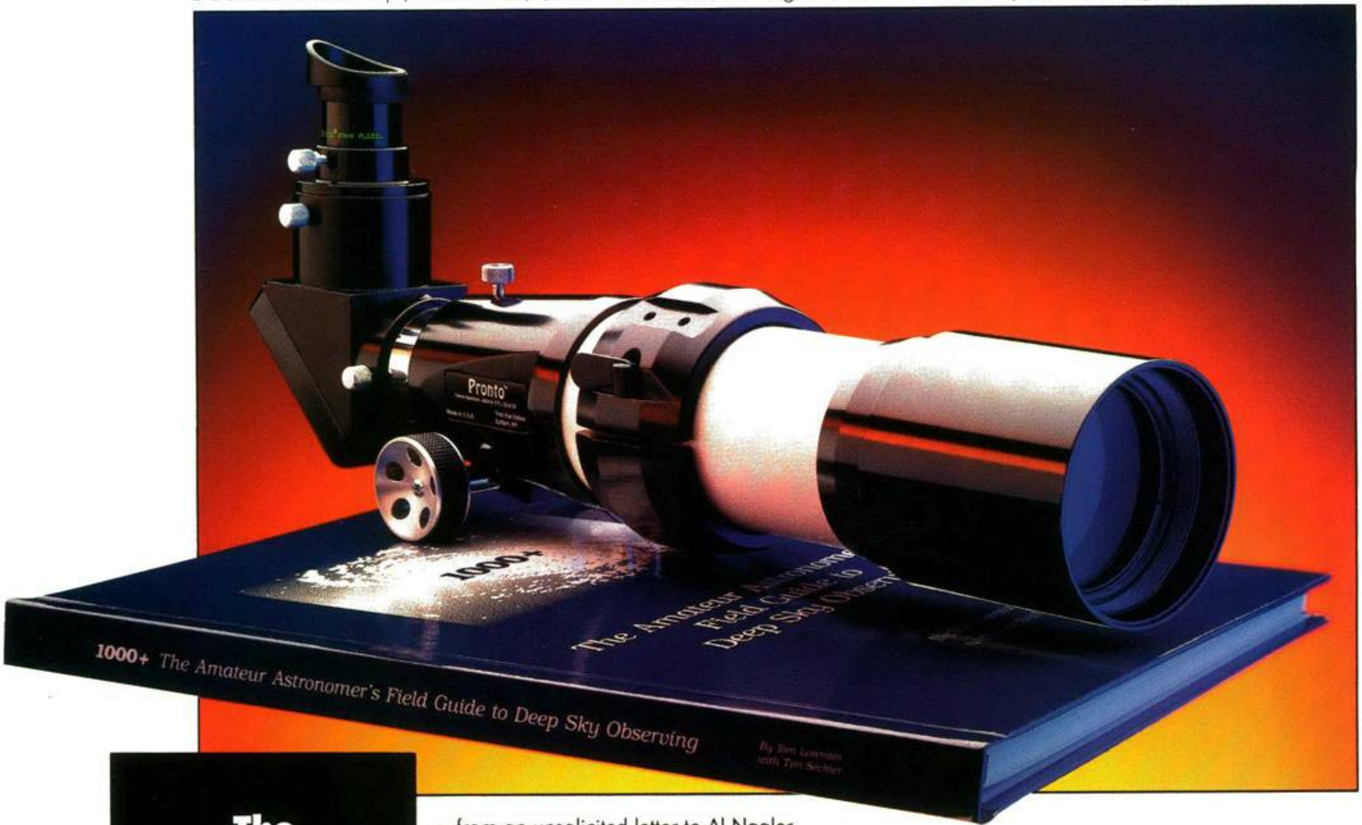
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– from an unsolicited letter to Al Nagler

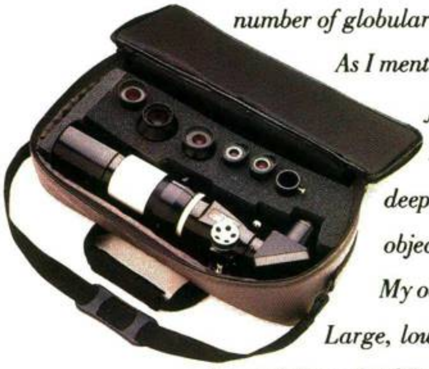
"Since I've been singing the praises of my Pronto to several people, I figure I'd better send you another note. During the November dark run, I used the Pronto on all or part of three nights. I made observations of 72 objects including a few double stars. Most of these observations were on a single night where the seeing was a little soft for the 6-inch refractor, but hardly noticeable in the Pronto. For me, the instrument's relative insensitivity to seeing is a great advantage, allowing good observing on nights I otherwise wouldn't go out.

The limiting stellar magnitude is between v=13.5 and v=14.0. This limiting magnitude is faint enough that a substantial number of globular clusters will be at least partially resolved.

As I mentioned before, the 30x eyepiece is my favorite for sweeping the Milky Way. I ended up using 50x for larger objects; 75x for 'ordinary' deep-sky viewing. A few high surface brightness objects were viewed to advantage at 110x, & I used 150x on double stars.

My observations show that from a true-dark site, the telescope is a real performer. Large, low surface brightness objects are routinely visible; even I was surprised by the visibility of NGC 147. Using the stars plotted on Uranometria, I traced the Andromeda galaxy to 4° length on two nights." – Brian Skiff, Author & Astronomer

Pronto photo of Eta Carina by Ralph Sieger



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